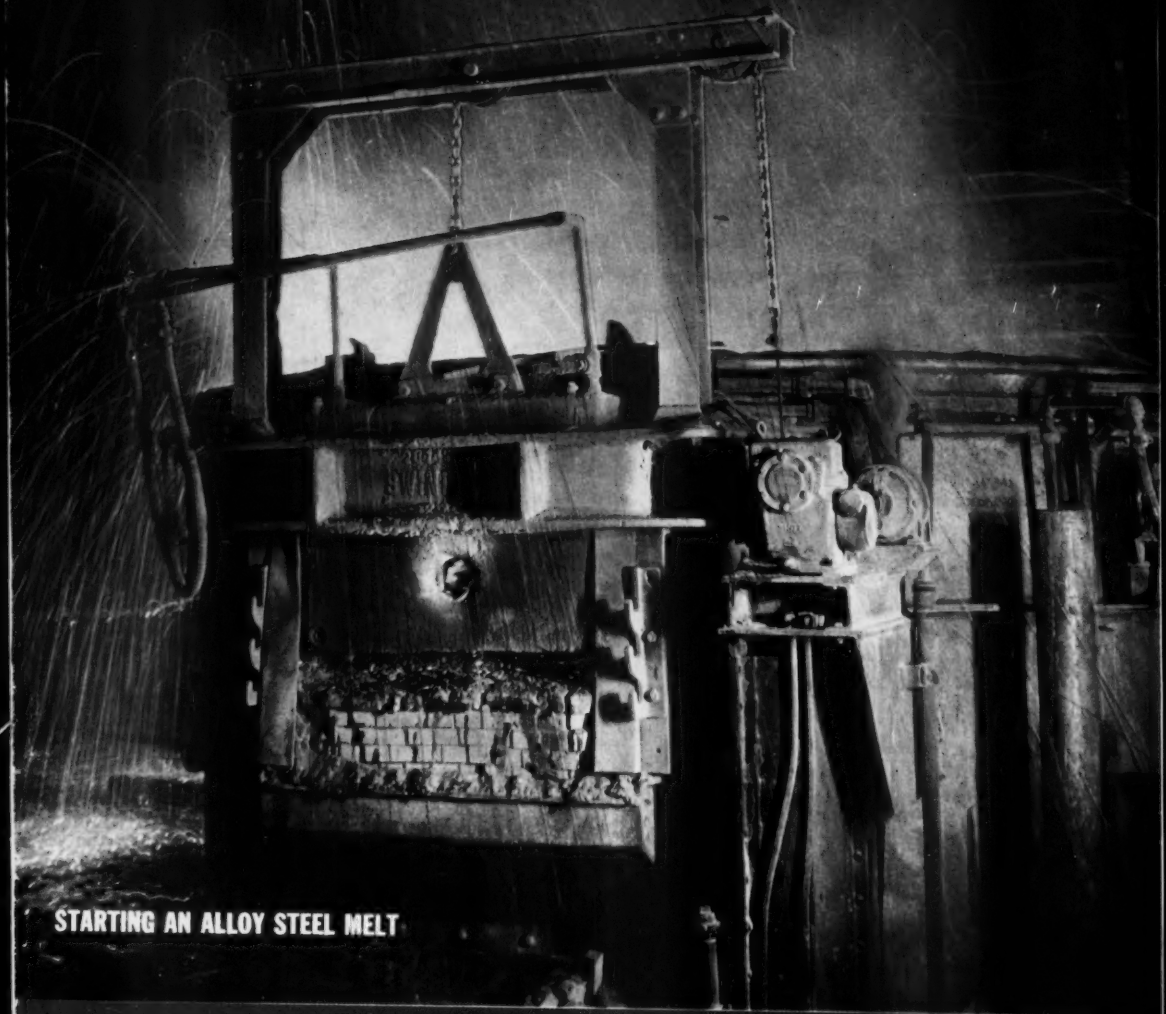
PRODUCT ENGINEERING

OCTOBER, 1949



STARTING AN ALLOY STEEL MELT

IN THIS ISSUE—The Metal Show + Low Alloy, High Strength Steels + Buckling of Stepped Columns + Journal Bearing Lubrication + Selecting Magnetic Relays

A McGRAW-HILL PUBLICATION

"FORMING OF AUSTENITIC CHROMIUM-NICKEL STAINLESS STEELS"

A Detailed, Authoritative Book

This new volume of more than three hundred 8¼" by 11" pages describes in detail, modern forming techniques as applied to austenitic chromium-nickel stainless steels. Tables of engineering data and more than two hundred engineering drawings are used to supplement the text.

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★

MECHANICAL PROPERTIES OF CHROMIUM-NICKEL STAINLESS STEELS

FORMING CHARACTERISTICS OF AUSTENITIC STAINLESS STEELS

PROCESSING AFTER FORMING

DESIGN, LAYOUT AND PREPARATION OF BLANKS

EQUIPMENT, TOOLS AND LUBRICANTS

BENDING AND STRAIGHT FLANGING

THE FORMING OF CURVED SECTIONS AND TUBING

FORMING OF CONTOURED-FLANGED PARTS

DEEP DRAWING OF CUP-SHAPED, BOX-SHAPED AND RELATED PARTS

DOUBLE-ACTION DIE FORMING OF DEEP- AND SHALLOW-RECESSED PARTS

FORMING OF DEEP- AND SHALLOW-RECESSED PARTS BY MISCELLANEOUS METHODS

FORMING OF SEMITUBULAR PARTS

EXPANDING AND REDUCING OF TUBULAR PARTS

Unexpected demand has exhausted the first two printings. but copies of the third printing may now be purchased through The International Nickel Company, Inc.

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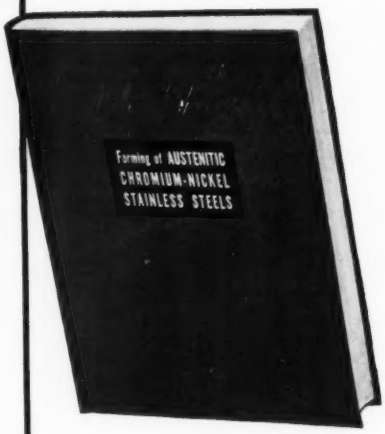

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Fabricators, Designers, Engineers and Others will find this book valuable.

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VOLUME 20 **PRODUCT ENGINEERING** NUMBER 10

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FRONT COVER—A 50-ton electric arc melting furnace being charged with high alloy scrap. Melting power is supplied through the three graphite electrodes. Kodachrome courtesy Allegheny Ludlum Steel Corporation

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A slim strand of wire brings city living to the farm. But interrupt that service and you plunge back a hundred years. Lights fail, water stops running, precious milk spoils. The automatic recloser guards this service by eliminating unnecessary power stoppages. This modern device assures more continuous electrical service to rural and suburban America.

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Contacts	Switches
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Resistance Welding Materials

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

STORAGE BATTERIES with twice the cranking efficiency of present types at -40 F are the result of two design improvements—vaporized lead oxide for the active material in the plates, and ultra thin plates that provide a significant increase in the total plate area within a given volume.

TITANIUM may develop into a major structural material within 5 to 10 years. The November issue of Product Engineering will present all the latest design data about the "hottest" material since stainless steel and aluminum came along.

TWO PERMANENT MAGNET MATERIALS will permit design economies for a variety of equipment. Alnico 5 has been modified so that the individual crystals are aligned in the direction of magnetization. Size and weight of instruments and motors can therefore be reduced. Highly coercive Alnico 7 will boost efficiencies in applications where a high demagnetization force is the primary consideration.

SILVER PHOSTUBE BRAZING ROD is replacing silver solder in applications where corrosion resistance, electrical conductivity or high ductility is required. In addition to having a melting point of 1,270 F and an as-welded tensile strength of 50,000 psi, the rod sells for less than most existing silver solders.

MOLYKOTE, TYPE Z, is a less expensive grade of the previously announced dry lubricant bearing the same trade name. (PE, Jan. '49, p 5) The molybdenum powder is chemically and thermally stable from subzero to 750 F, has high strength as a bearing film that prevents galling and seizing at bearing pressures of 100,000 psi and above. Makes an ideal thread lubricant.

THE PROPERTIES AND STRUCTURE of cast iron are significantly affected with the addition of boron. Hardness, transverse strength and depth of chill increase noticeably as boron content goes up. At the same time, the size and quantity of graphite particles decreases and undercooling becomes more pronounced.

ALUMINUM FOIL is fast becoming the No. 1 parts packaging material in the radio and aircraft industries. Selling points are moisture resistance, nonflammability, heat conductivity, affinity for printing inks and attractive appearance.

Nonmetallic Materials

NEW LAMINATED PHENOLIC is highly resistant to impact and easily machined, yet retains desirable electrical and chemical characteristics. A cotton mat filler with long fibers extending in all directions instead of in parallel planes does the trick. Strength is distributed, wear more uniform. Comes in 3-ft square sheets in natural tan color or black of different thicknesses.

"ELASTIC" LUBRICANT solves the problem of frequent relubrication of plug-type valves. Compressibility and expansibility of Hypermatic insure 100 percent lubrication for extended periods and serve as a safety medium to fill voids in the event of leaks. Operating pressures can vary from 50 psi to capacity of valve, temperatures from subzero to 250 Fahrenheit.

LATEST THING in fire protection is a paint that creates an inch-thick, marshmallow-like insulating substance when exposed to flames or extreme heat. Unlike existing fire retardant coatings that flake, material is a water-

Continued on Page 5

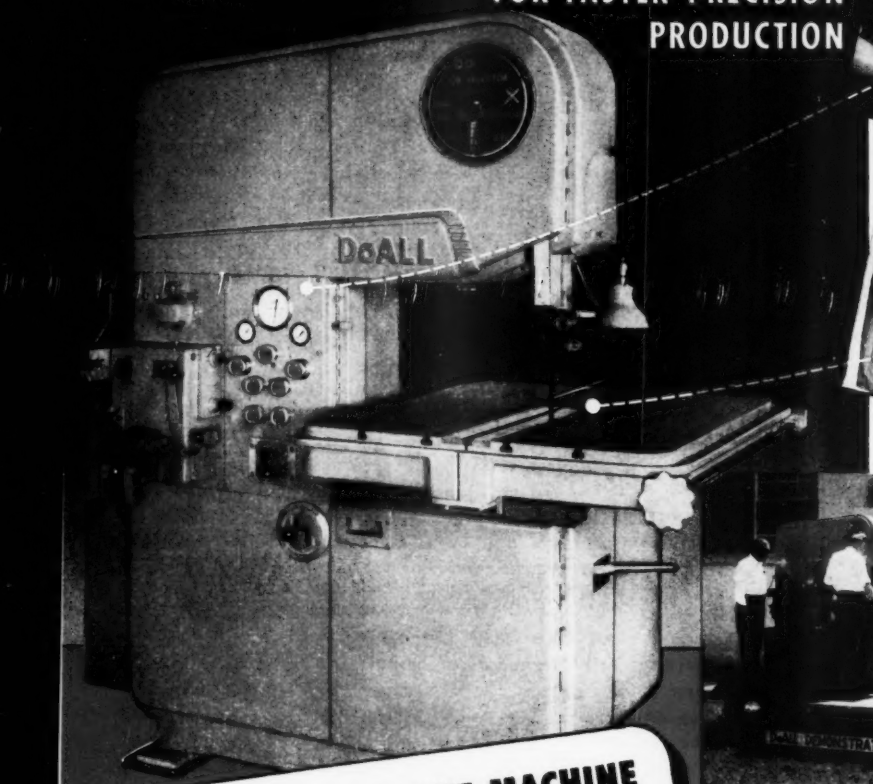
DoALL's

MANUFACTURING MACHINE TOOL

THE NEW

Contour-matic...

HAS **55** NEW FEATURES
IN ITS ADVANCE DESIGN
FOR FASTER PRECISION
PRODUCTION



Complete speed range from 40 to 10,000 f.p.m. to cut all materials most efficiently

Finger tip operation is centralized at this panel containing all automatic controls

Work Table is hydraulically operated and designed for holding the work

Now with ONE MACHINE
Cut every METAL!

PLUS ANY OTHER SOLID MATERIAL

Employs 244 different band tools for machining, sawing, grinding, honing, filing, slicing, friction sawing and polishing

DoALL *Company*

Des Plaines, Ill., U.S.A.

powder mixture resembling clear varnish. A wooden panel treated with the product does not become charred after being subjected to flames from a blow torch for 25 minutes.

TELEVISION with sharp contrast and reduced glare is the selling point for one company's late model receiver. A new tube face material,

called Teleglas, is the secret. Three metallic oxides in the glass absorb room light and minimize halation – the halos of light formed from reflections within the tube face itself. A 35 to 1 ratio of contrast under widely varying conditions of room light is the result.

COMBINATION spatter-proofing and rust-preventive compound for welded steel is effective for six months outdoors and two years indoors. Coating prevents adhesion of flash and weld spatter, saves up to 85 percent of the time needed for cleaning welds. Applied by brush, spray or dip, compound also serves as a base for paint.

Processes

A ONE-STEP TECHNIQUE for brazing non-metallics such as ceramics, carbides, sapphires and diamonds to metals. Titanium or zirconium hydrides, special copper-silver eutectic alloys melting at 1,435 F or even pure silver of aluminum can be used to form the bond.

CONTRARY to general belief, pretinning and soft soldering of cold-rolled copper sheet do not cause softening with a resultant loss of

hardness and strength. Tests indicate the highest temperature generally reached is only 570 F. When copper is overheated to 700 F for a minute, no measurable softening occurs; at 750 F a temperature at which tinning is not satisfactory, softening of the copper sheet is noticeable.

ZIRCONIUM is yielding some of its secrets to hard-working scientists. Arc, high frequency, and split-tube graphite resistor-type furnaces have been used for melting the rare metal that fuses at 3,090 F. A three-phase model of the resistor furnace has proven most successful; and ingots of the chemically-active material have been cast by the bottom-plug crucible method in this type furnace.

ELECTROPLATING of Ni, Cd, Cr, Zn, Ag and other metals on magnesium and its alloys is a three-step operation – zinc coating by immersion, copper striking to a thickness of 0.0005 to 0.0008 in. and then plating in standard baths. Unalloyed or pure magnesium calls for dilution of fluorides in the bath concentrate.

Components

IMPROVED TV TUBES have a bent electron gun that incorporates a single ion-trap magnet – result, no ion-spot blemishes. Since the beam is bent only once, screen spots are undistorted and picture resolution augmented.

NO ELECTRIC CURRENT is needed for a new type fluorescent light – as long as the

tube is agitated it will continue to glow. An electrostatic charge set up by the interaction of mercury and phosphor causes low-pressure argon or neon to glow. Different fluorescent powders can be used to produce a variety of colors. Tubes can be made in any shape.

SMALL D-C GENERATOR delivers output voltage proportional to acceleration rather than velocity of rotation. Change in velocity of a drag cup non-magnetic rotor turning in a fixed d-c field induces a proportional voltage in a secondary winding located 90 deg in space from exciting field. Applications include computors, aircraft controls and servo systems where acceleration must be measured or limited.

STREAMLINED HANDLE MECHISM for circuit breaker and control cabinets is slam-proof. Three locks are provided – one for the "off" position, a second for the "on" position and a third for emergency adjustments when the power is on.

SOFT RUBBER ABUTMENTS in the center grooves of large packing rings prevent "rolling" during reciprocation of shafts. This

Continued on Page 7

Electrical connector molded from Hycar rubber by Mines Equipment Company, St. Louis, Missouri.

It handles "HOT JUICE" for planes—SAFELY

YOU'VE often seen air liners getting under way at an airport. A serviceman brings out a portable electric generator, plugs it in, gets the plane's huge engines going.

The plug that connects the electricity to the plane has a vital part in this job. And the plug pictured above *more* than meets the tough service requirements. It's made of Hycar OR-25 EP (easy processing), a special oil-resistant American rubber with outstanding advantages.

Hycar OR-25 EP resists heat generated by current, stays flexible at high temperatures. It resists oxidation, aging, weather and wear. Most important—it resists abrasion and chipping, and neither oil nor grease will harm it.

Hycar Reg. U. S. Pat. Off.
American Rubber

Important production economies, such as shorter mixing cycles, are made possible by the superior processing characteristics of Hycar OR-25 EP. Find out the many ways that versatile Hycar may be used to help build your sales and profits. For complete information, please write Dept. HJ-10, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

B. F. Goodrich Chemical Company A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

Vee-Dam design insures complete sealing of each ring and does away with labyrinth flow.

BALL BEARINGS made of beryllium copper are gaining favor in applications where corrosion resistance and non-sparking are major considerations. Though these non-magnetic bearings are not as hard as the steel counterparts, their load carrying capacity more than compensates because of high fatigue, resistance.

SOLENOID-ACTUATED PEN avoids ink-throwing while affording speedy recording on circular-chart electronic potentiometers. Amplifying linkage is designed so that the solenoid's high-velocity movement is almost complete before the pen is picked up.

Products

ELECTRIC FLAMELESS HEAT GUN that projects up to 1,200 F of radiant heat is adaptable to most of the usual applications

for a blow torch. Direct flame brazing or soldering is the only exception. Absence of an open flame permits the use of the Thermal Jet for softening or welding plastics and other materials that will not resist flame temperatures.

AN AUTOMATIC DEVICE controlled by a gyroscope takes the "Dutch Roll" or tail-swaying motion out of jet planes. Gyroscope senses impact of wind gusts and actuates a motor that moves the rudder.

TURBINE-TYPE PUMP with a "floating" impeller is not subject to "freezing" during temperature changes, bearing rust or improper lubrication. Wheel is secured to an enlarged shaft by a lock nut and woodruff key, thereby reducing metal-to-metal contact. Compensation for endplay is made with a proloaded spring under the outer adjusting nut.

PERSPECTIVE DRAWING INSTRUMENT automatically guides pencil toward established vanishing points from any spot

on the board. A system of three scale arms controlled by piano wires strung around pulleys is the heart of the Perspect-O-Metric. Brake levers lock the arms while lines are being drawn. Isometric drawings can also be made. Instrument is attachable to parallel-ruling straight edges.

FLUORESCENT STREET LIGHT is virtually glareless. Fixture is a cigar-shaped aluminum tube containing two pairs of 8-ft fluorescent lamps. Two highly polished reflectors, mounted back to back, direct the light through clear plastic windows onto the pavement.

Testing

A DAILY DIARY is written in dust by a simple instrument that determines the extent of air contamination for a given area. A jet tapered to a fine slit samples air continuously. Particles in the samples are deposited on a revolving glass disk that is calibrated for any desired period from a minute to a week.

QUALITY CONTROL of metal sheets less than 0.005 in. thick can be more accurately maintained by subjecting them to "bulge"

tests rather than to conventional tensile tests. Correlation with the actual formability of a metal is so close with this new method that an ASTM committee is considering the standardization of such a test for all the materials that are classified as foil.

SENSITIVE TACHOMETER for checking vehicle speeds over rough terrain utilizes a bicycle wheel that spins a small generator. Inaccuracies caused by ground slippage are therefore avoided. A voltmeter registers the generator's output in miles per hour.

SUPER MICROSCOPE that "sees" has mirrors instead of lenses. Instrument will permit the use of infra-red rays for

spectral analysis and identification of chemicals. A small spherical convex mirror and a large aspherical concave mirror do the magnifying. Both are made of speculum metal coated with a reflecting layer of aluminum.

A NEW-STYLE GALVANOMETER – the Contact Modulated Amplifier – will withstand more than the usual amount of shock. Vibrations of considerable magnitude do not upset the instrument's calibration and electrical impulses as small as a few hundredths of a microvolt can be measured.

Inside story of the

300 TANKS

made for rugged

ALASKAN SERVICE

They're fabricated from

REVERE HERCULOY

The silicon-bronze alloy of great strength and corrosion resistance

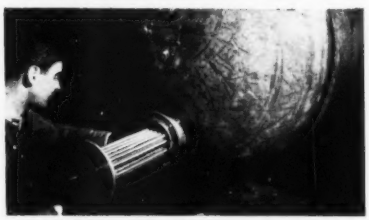
ALASKA is no place for sissies, whether they be men, metals or alloys. Rugged service calls for rugged materials. That's how Revere Herculoy came into this picture. The tanks illustrated, which had to be made to a combination standard of ASME and Army specifications, are of 1250 gal. cap. and made for a working pressure of 127½ lbs. Each tank receives a 300 lb. hydrostatic test before shipment.

Herculoy was chosen for this job because of its unusual properties. This silicon-bronze alloy has the corrosion resistance of copper with the strength of medium carbon steel. It cold-works and hot-works readily and is easily welded by any of the commercial methods, its thermal conductivity being roughly only 10% of that of copper and comparable to that of mild steel, thus high thermal losses of conduction are not encountered. In the case of the tanks shown the welding method employed was the Heliarc process, using ¼" Herculoy rod. Tanks were welded both inside and outside.

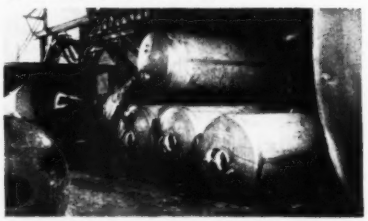
Herculoy also has superior fatigue resistance, and is used in operations requiring resistance to alternating and cyclic stresses. It is but one of the many Revere Metals and Alloys and combinations of alloys being used more and more by more and more industries for the really tough jobs. For these industries have found there are many uses for copper and copper alloys of which they had never before dreamed . . . uses that have resulted in substantial savings, longer life, improved performance. They have also found that because of the many years of experience working with copper, Revere Technical Advisory Service can be of real help in solving many of their problems.

So, before placing your next order, why not call the Revere office nearest you?

ROLL OUT THE TANKS—Here you see a sheet of Revere Herculoy being rolled into cylindrical shape at the H. AMICK SHEET METAL WORKS, Seattle, Wash. Heads are then welded onto both ends of these cylindrical shells.



HOT SHOT FOR COLD TANKS—After welding is completed a removable heating element made of Revere Copper tube is placed into the tank. These elements range in sizes of from 3 sq. ft. of surface to 750 sq. ft.



HEADED FOR THE FROZEN NORTH—These completed tanks awaiting shipment are 48" x 168" and are the largest of the group of some 300 made of Revere Herculoy by H. AMICK SHEET METAL WORKS for use in Alaska.

REVERE

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"PACKAGED POWER"

That's Shockless—Trouble-Free!

LINK-BELT *Electrofluid* GEAR DRIVES WITH SILVERLINK ROLLER CHAIN

The Ideal Slow Speed Drive

The advantages of the Electrofluid Drive are available on virtually any power application through combination with other Link-Belt enclosed gear and chain drives. Above is shown one such combination which will afford shock-proof, economical power transmission at low speed.

Three principal advantages of this drive are:

(a) It provides smooth power transmission, assuming the load gradually and eliminating shocks which could damage material in process.

(b) It prevents damage to costly power-driven equipment and eliminates work stoppages.

(c) It permits the use of a smaller motor than ordinarily required to handle starting loads—improves power factor and overall efficiency.

Ask for Book No. **2085-B** giving full details and application suggestions.

TYPES OF LINK-BELT Power Transmission Machinery

- Silverlink Roller Chain
- Silverstreak Silent Chain
- Steel and Malleable Chain
- Worm Gear Drives
- Herringbone Gear Drives
- Helical Gear Drives
- Gearmotors
- P.I.V. Variable Drives
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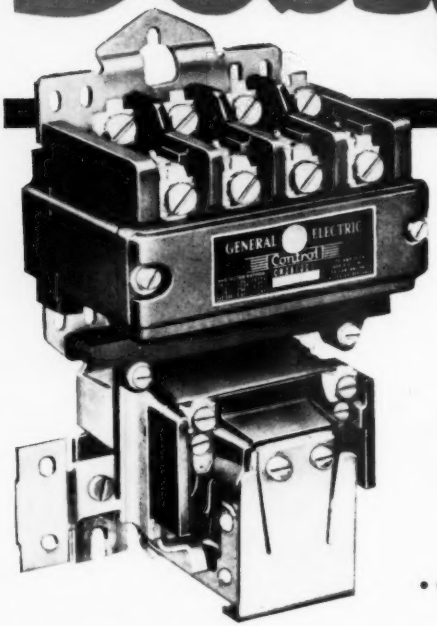
LINK-BELT

Power Transmission Machinery

"THE COMPLETE LINE"

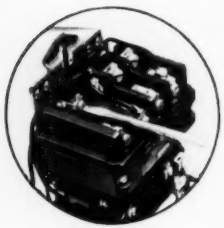
Designer's



Designed to be used with the greatest of ease!

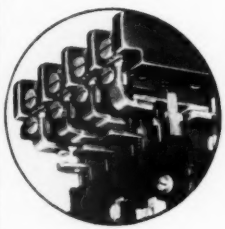
Magnetic Contactors

...in a complete, all-new line



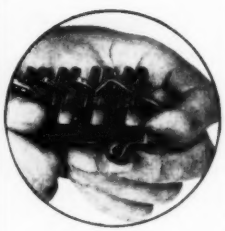
EASY TO WIRE

All terminals can be reached from the front; large pan-head screws give ample bearing surface for screwdriver. Just strip wires, slide them under terminal clamp which rides out with the screw, and tighten screw. These new G-E a-c contactors are available in NEMA sizes 00, 0, 1, 2, and 3, rated up to 50 hp at 440 volts.



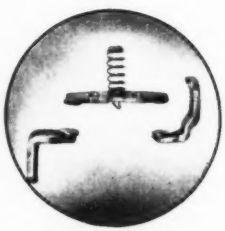
EASY TO INSPECT

By loosening two captive screws to lift off the burn-resistant arc hood, you quickly, completely expose the contacts, simplifying inspection and maintenance. All contacts can be removed without disturbing connections to terminals. A screwdriver is all you need for inspection.



EASY TO CHANGE CONTACTS

In sizes 00, 0, and 1, contacts can be changed from normally open to normally closed (or vice-versa) with no extra parts. Just remove two screws and take out the moving contact head. Then depress the spring slightly (it's held in place permanently), roll out and reverse the contact.



EASY TO CHANGE INTERLOCKS

To meet individual control circuit needs, interlocks in all sizes can be changed from normally open to normally closed, just like the main contacts. Extra double-circuit interlocks with interchangeable contacts are quickly added to either side of the contactor. This means *four* extra interlocks! See Bulletin GEA-5154.

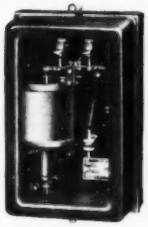
GENERAL ELECTRIC

Digest GE PRODUCT HIGHLIGHTS

SENSITIVE RELAYS

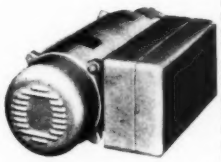
FOR MANY OPERATIONS!

Need a highly sensitive, extremely accurate device to control, protect, or regulate an operation? You'll find the right one among General Electric's standard Type GTR a-c and d-c relays. Unlike ordinary relays, these devices are made to operate on minute frequency, voltage or current changes in a circuit, and, where necessary, to initiate corrective action. Enclosure is dust-tight and moisture proof. See Bulletin GEA-2961.



AMPLIDYNE PLUS AMPLIFIER

EQUALS BETTER CONTROL!

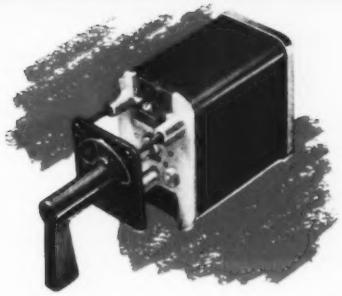


Note the many ways the General Electric electronic amplidyne can help in many types of motor control where you need precise regulation of current, voltage, and speed. With this versatile packaged unit, you can cover wide speed ranges, limit loads, hold tension, speed up acceleration, and position accurately. Providing instant response and high amplification, the G-E electronic amplidyne can be applied to the control of motors from $\frac{1}{4}$ hp to 200 hp. See Bulletin GEA-4889.

STURDY SPACE-SAVER

—THE SIZE 2 SWITCHETTE!

Where space is limited, use this compact, sturdy General Electric Size 2 Switchette to control small-motor drives, for limit-switch applications, and in various electronic, industrial heating, and other control circuits. Approximately 2 x 1 x 1 inches, it weighs only two ounces. Snap action, double-break-contact construction gives it a current rating up to 25 amperes at 230 volts a-c or 24 volts d-c—makes it withstand severe vibration. See Bulletin GEC-207.



Switch to the Switch

WITH 10,000 USES!

Yes, more than 10,000 circuit combinations and operation sequences are possible with this versatile control and tranfer switch—the General Electric Type SB-1. Because its many *standard* cams, contacts, fingers and other parts are interchangeable, you can use it for practically any control job on almost any low-capacity circuit. Construction features include silver-to-silver contacts, anti-arcing barriers between adjacent circuits, and sturdy Textolite face plates.

For extra-heavy duty, the rugged Type SB-9 has all these features plus wear-resistant extra strength built into every part—contacts, gears, shunt connections, and even the handles.

Both the SB-1 and SB-9 mount on panels $\frac{1}{8}$ to 2 inches thick, are rated up to 20 amperes at 600 volts a-c or d-c. And standards are ready on only four weeks' delivery! See Bulletins GEA-4746 (SB-1), and GEA-4114 (SB-9).

General Electric Company, Section C668-76
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ **GEA-2961—Type GTR relays**
- ☐ **GEA-4114—Type SB-9 switch**
- ☐ **GEA-4746—Type SB-1 switch**
- ☐ **GEA-4889—Electronic amplidyne**
- ☐ **GEA-5154—A-c motor contactors**
- ☐ **GEC-207 —Size 2 switchette**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

Company .....

Street .....

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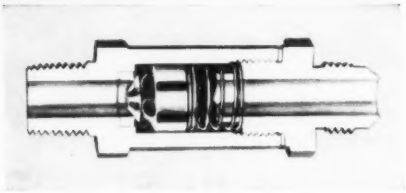
Cone-type check valves illustrated have an operating pressure up to 1500 PSI with a burst pressure of 3750 PSI. Excellent for use with hydraulic fluids, gasolines, oils, water, and acids non-corrosive to aluminum.



Metal-to-metal seats are best suited for high pressures, extreme temperatures, and corrosive fluids.

Specify KOHLER CHECK VALVES

for long service life

The complete line of Kohler Precision Parts includes check valves for all aircraft, industrial and automotive installations. Leading manufacturers specify Kohler valves for lines using hydraulic fluids, gasolines, lubricating oils, aromatic fluids, air, vacuum, water, acids, chemicals, etc.—and requiring a *pressure regulating valve, pressure relief valve, vacuum breaker, restrictor check, check valves with high or low opening pressures or check valves for special applications.*

All major types, cone, soft seat, and swing checks, have been developed to meet rigid service requirements. The superiority of Kohler designs and precision manufacturing processes have been demonstrated by valves in actual use. Kohler valves have quick opening and positive closing without poppet chatter or leakage. When they are open, free flow is maintained with minimum pressure drop.

Kohler engineers will gladly cooperate in developing precision parts for your special requirements. Write for our new catalog, showing the full line of Kohler Precision Parts, with specifications, engineering data and useful information.

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KOHLER CO., Dept. 17-J, Kohler, Wisconsin
Please send your new Catalog to:

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KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS

PLENTY TOUGH when the going's ROUGH!

LAMSON "1035" CAP SCREWS

Toughness . . . Strength . . . Precision

Accurately headed, precision threaded and *plenty rugged*—that, in a nutshell, describes Lamson "1035" Cap Screws.

Lamson pioneered the "high tensile" Cap Screw after years of research and "on the job" testing.

Today's "1035" product is precision-made on the finest type of bolt-making machinery—and heat-treated automatically in furnaces where the atmosphere is scientifically controlled.

As a result, the modern Lamson "1035" Cap Screw is unmatched for strength, toughness and all-round quality.

That's why you'll be way ahead always to say "Lamson" *before* you say "Cap Screws."

THE LAMSON & SESSIONS COMPANY

General Offices: 1971 West 85th Street, Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Lamson & Sessions

"One Dependable Source for All Fastener Needs"

SEMS	LOCK NUTS	NUTS	STUDS
STOVE BOLTS	LAG BOLTS	WASHERS	RIVETS
TAPPING SCREWS	ROPE CLIPS	SET SCREWS	PLOW BOLTS
"1035" CAP SCREWS	MACHINE BOLTS	CARRIAGE BOLTS	COTTER PINS

—CUT ALONG THIS LINE—

WANT MORE INFORMATION on any of these fasteners? CHECK—and CLIP this strip.

○ **LAMSON LOCK NUTS:** Economical, vibration-proof. Can be re-used repeatedly.

○ **"1035" SET SCREWS:** Cup point type, hardened, heat-treated.

○ **COTTER PINS:** Steel, Brass, Aluminum and Stainless Steel.

○ **SPECIAL NUTS:** Cone, Barrel, Oblong, Plier, Tri-Slot, Half-round, etc.

○ **PHILLIPS AND CLUTCH HEAD:** Machine Screws and Tapping Screws.

○ **MILLED STUDS:** Concentric, accurate, in a full range of sizes.

○ **"BENT" BOLTS:** Including U Bolts, Eye Bolts, Hook Bolts, etc.

○ **WEATHER-TIGHT BOLTS:** Eliminate counter-boring in wood assemblies.

○ **PIPE PLUGS:** Forged Steel, heat-treated.

The Lamson & Sessions Company
1971 W. 85th St., Cleveland 2, Ohio

NAME

POSITION

COMPANY

STREET

CITY ZONE STATE

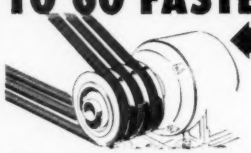
NEW TEXROPE AUTOMATIC SHEAVE

NOW.. Get Lowest Cost

One Hand
Does it...

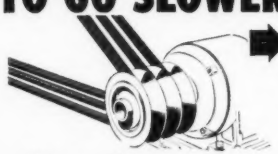
WHILE MOTOR IS RUNNING

TO GO FASTER



Move Motor Forward Toward Driven Machine

TO GO SLOWER



Move Motor Back From Driven Machine

Originators of the Multiple V-Belt Drive for Industry!

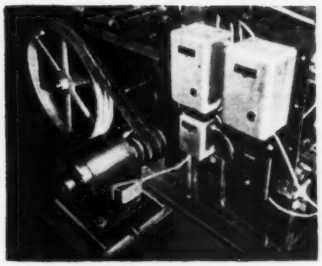
ALLIS

AIDS PRODUCT DESIGNERS

Instant Speed Control

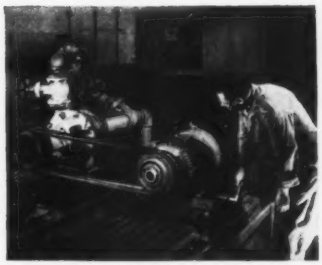
TEXTILE

AUTOMATIC SHEAVE changes speed of spinning frame in seconds while in motion. Replaces more expensive method of changing speed. Here, operator quickly obtains best operating speed to suit thread strength and size. Speed can also be changed to suit various operators.



WOOD PRODUCTS

CORING MACHINE uses automatic sheave and Allis-Chalmers induction motor and control. Instantly variable speed with 2 to 1 speed range greatly increases output at small original cost. Motor operates at 900 rpm with driven shaft speed adjustable from 120 to 228 rpm.



PUMPS

PERFECT SOLUTION to varying head and capacity of pump at same time maintaining efficiency. Where pumping requirements vary, pump can be instantly adjusted to supply more or less liquid as desired. Pump illustrated is solids handling pump driven by 10 hp enclosed motor.

MACHINE TOOLS

HIGH MACHINE PRODUCTIVITY is number one advantage of instantly adjustable Vari-Pitch Automatic drives. Constant cutting speed is now easily obtained at lowest cost for grinders, buffers and polishers . . . plus the inherent shock-absorbing advantages of Texrope V-Belts Close control of periphery speed means higher efficiency grinding and polishing, as well as prolonged grinding wheel life.

Vari-Pitch Automatic Sheaves offer the same advantages for punch presses, engine and automatic lathes, drill presses and many other types of machine tools. Why not investigate the possibilities of using this new sheave in your product? You'll find an Allis-Chalmers Texrope drive expert at your nearby A-C Sales Office. He'll be glad to show you how Vari-Pitch Automatic Sheaves can be applied to your product.

NEW VARI-PITCH AUTOMATIC SHEAVE covers most speed changing needs from 3 to 40 horsepower . . . gives you instant *stepless* speed control for machines at lowest possible cost! It changes pitch diameter and holds belts at proper tension *automatically!* Gives you 100% speed increase; 2 to 1 range.

Machine designers and original equipment manufacturers are already using this new sheave to increase machine versatility . . . at costs only a fraction more than for other type of speed control.

Send for details on this great new advancement today. Learn how it can be applied to your problems at new lost cost. And for additional information on other A-C products for the OEM field — pumps, motors, controls, voltage regulators — check your needs in the coupon below.

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

A-C ALLIS-CHALMERS

CHALMERS

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

Please send me the literature checked below:

Automatic Sheaves—Bulletin 2087223 ☐

Handy Guide for Electric Motors — Bulletin 5186052 ☐

Rocking Contact Voltage Regulators —
Bulletin 1386035 ☐
Bulletin 1486143 ☐
Bulletin 1486137 ☐

Vari-Pitch Sheaves—Bulletin 2086082 ☐

Speed Changers—Bulletin 2086013 ☐

Switchgear and Control Devices — Bulletin 2587095 ☐

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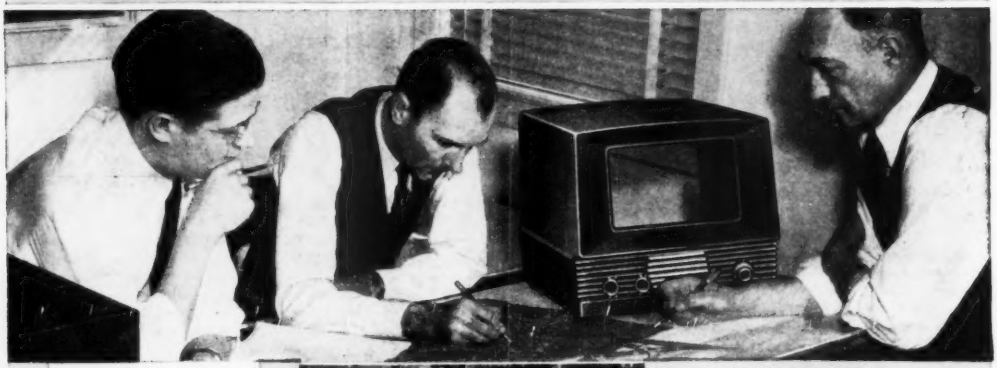
It pays to use your custom molder's know-how

says Philco, meeting low-cost TV demand

No. 10 in a series on Plastics Skill at Work . . .

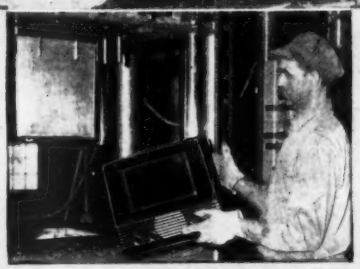


PROJECT:
Twelve-pound television receiver cabinet in one piece

CUSTOMER:
Philco Corporation
Philadelphia, Pa.

MOLDER:
American Insulator Corporation

MATERIAL:
Durez mottle phenolic plastic



VERIFIED ACCURACY. Sample of finished molding is turned over to engineers for checking all measurements according to Philco specifications. Photo shows cabinet as received from press operator.

SIMPLE PRODUCTION. Cabinet is ejected from hydraulic press at custom molder's plant with all holes, lugs and bosses molded in. Smooth, glossy surface is integral and requires no finishing operations.

● Whenever a salesman in any of the thousands of Philco dealers' showrooms starts a sales talk on this new televison model, he is demonstrating the result of manufacturer-molder cooperation.

And whatever *you* make, wherever it is used, whoever buys it, there is very likely in your product a place to use a custom-molder's know-how as successfully as Philco. Lower material costs, economies in finishing, faster production, better appearance, or longer product service are among the potential benefits.

Philco is familiar with all these as a big user of phenolic plastics for years. Although the cabinet of this receiver was to be a complicated one-piece form weighing no less than 12 pounds, they confidently handed the problem of producing it to well-known molders. Shaped in American Insulator's presses, the housing needs no machining, no gluing, almost no finishing . . . and because it is Durez mottle it has a rich, wood-colored finish of permanent natural luster. Quality of performance both visual and aural is safeguarded by the high dielectric strength of the Durez.

The valuable services of skilled custom molders, as well as experienced Durez phenolics specialists, are at your call for consultation and planning.

A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 1510 Walck Rd., N. Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

UNBRAKO

The Knurling SAVES TIME...

ASSURES A SLIP-PROOF GRIP, EVEN WITH OILY, GREASY FINGERS

There is a definite saving of assembly time when you use "UNBRAKO" Socket Head Cap Screws. The exclusive knurled heads perform triple duty: (1) the *knurling* provides a sure, slip-proof grip; (2) the *knurling* speeds assembly, because it enables the "UNBRAKO" to be screwed in faster and further with the fingers—handiest of all wrenches—before a "key" becomes necessary; (3) the *knurling* permits positive locking—a feature so often essential where there is excessive impact or vibration.

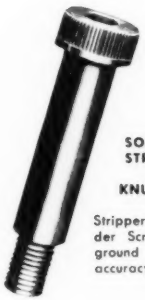
As always, the brand name "UNBRAKO" signifies *extra strength* and *precision manufacture to close tolerances.*

"UNBRAKO" *Knurled* Socket Head Cap Screws are available in both National Coarse and National Fine Thread Series in a full range of standard sizes. Other sizes to special order. Our "UNBRAKO" Catalog gives you further details—write for it and for the name of your nearest "UNBRAKO" Distributor.

Knurling of Socket Screws originated with "Unbrako" in 1934.

OTHER POPULAR "UNBRAKO" PRODUCTS

"UNBRAKO" *Knurled* Cup Point or *Knurled* Thread Self-Locking Socket Set Screws; "UNBRAKO" *precision-ground* Dowel Pins . . . of hardened alloy steel; "UNBRAKO" *fully-formed* Pressure Plugs . . . in either regular or "Dryseal" types.



SOCKET HEAD STRIPPER BOLT WITH KNURLED HEAD

Stripper Bolt or Shoulder Screw—precision ground for maximum accuracy

SOCKET SET SCREW WITH PLAIN CUP POINT

For use where Self-Locking is not necessary, the "UNBRAKO" Socket Set Screw with *plain cup point* has proved highly satisfactory. Sizes available from # 4 to 1½" diameter, in a full range of lengths.

FLAT HEAD SOCKET CAP SCREW

The "UNBRAKO" Flat Head Socket Cap Screw is representative of the popular "UNBRAKO" Internal Wrenching feature . . . and of "UNBRAKO" *extra strength* and *precise close tolerances.* Available in sizes from ¼" to 3" diameter, in a full range of lengths.

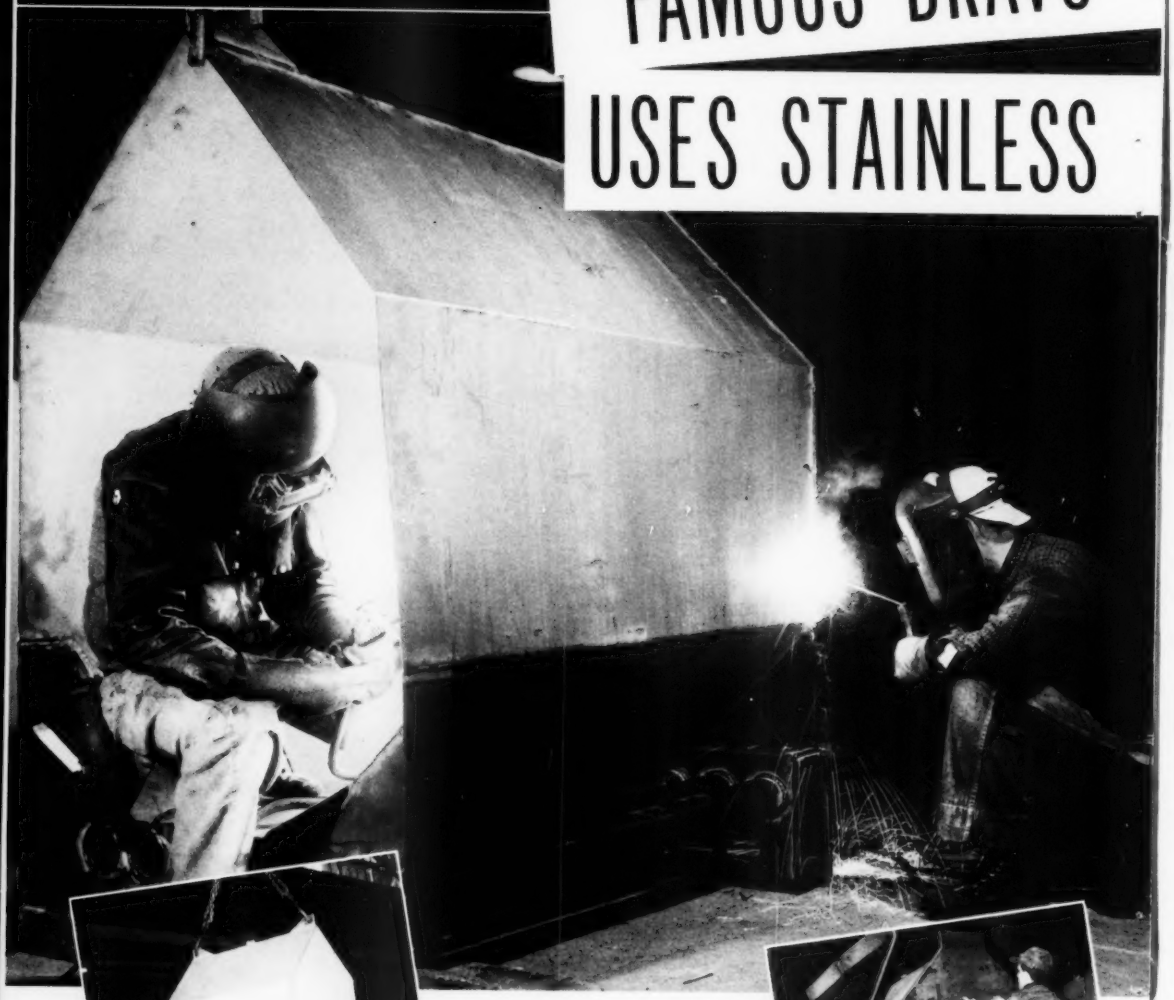
SPS STANDARD PRESSED STEEL CO.

BOX 545 JENKINTOWN, PENNSYLVANIA

"Serving Industry continuously since 1903 through Industrial Distributors"

Who said it costs more to use Stainless Steel?

FAMOUS DRAVO USES STAINLESS

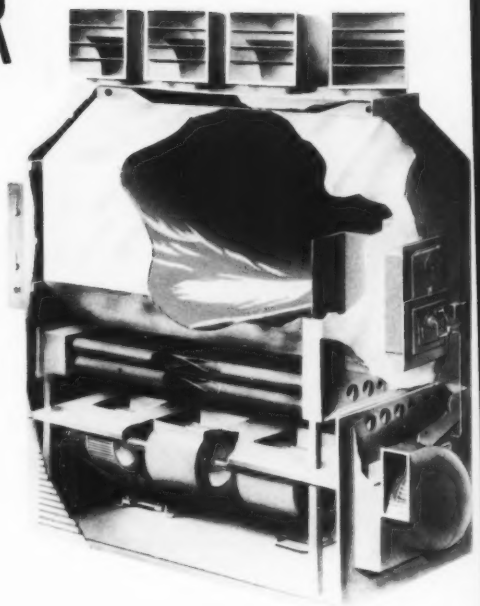


(Above) The Stainless Steel combustion chamber —the "heart of the heater"—takes finished shape. Note the simplicity of construction. Outer seams are continuous-welded, inside seams are intermittent. *(At left)* The completed Stainless chamber goes into the frame as a unit.

(At right) Outer casting goes on. Fastened with sheet metal screws, panels can be easily and quickly removed. Asbestos gaskets make joints air-tight. Mass production methods insure uniform, speedy manufacture.

Counterflo HEATER

TO REDUCE COSTS!



Completely self-contained, automatic in operation, this direct-fired heater provides an entirely new solution to the troublesome problem of plant heating. A "single-package" heating unit that can be positioned anywhere, it supplies heat directly to the area needing it, efficiently and economically.

Incidentally, it also proves that using Stainless Steel does not necessarily increase cost, but on the contrary, can decrease it.

THE heart of any heater is the combustion chamber. In the original Dravo Heater sold by the thousands to army camps and plants during the war, this chamber was made of corrugated carbon steel lined with refractory cement. Numerous fins and deflectors were welded to its outer surface.

To meet the tremendous civilian demand created by its highly successful war-time service, Dravo engineers recently redesigned the heater to increase its efficiency, to reduce its size and weight, to increase its life span, to make its operation safer. And in order to maintain prices in the face of rising labor and material costs, they took steps to speed up its production and to reduce manufacturing costs. They accomplished these things mainly by building the combustion chamber of Stainless Steel.

By specifying Stainless Steel that withstands temperatures up to 1600° F. they got rid of the troublesome and maintenance-demanding refractory lining. The unlined chamber, with its entire surface now exposed to the flame and gases, greatly increased heat transfer. This made it possible to eliminate fins and deflectors, allowed them to build the chamber smaller (to reduce its heating surface 53% without reducing operational performance) . . . and to reduce its weight 1500 pounds.

In addition, the simplified chamber design obtained by the use of Stainless Steel reduced the number of fabricating operations from 95 to 67. And, even though welding with Stainless requires more care, welding costs too were reduced because only 186 lineal feet of welding were required instead of 400 feet.

● To indicate how U·S·S Stainless Steel might benefit *you* in similar constructions, we recapitulate the benefits Dravo has obtained by using Stainless:—It has enabled them to employ less expensive manufacturing procedures than those used previously. It has insured greater portability for their equipment. It has improved heat transfer and eliminated expensive refractory maintenance. Dravo is now sold on the use of Stainless Steel because, as their engineers report, it has given them a tremendous advantage over competition in many respects, one of the most important being *lower cost of manufacture.*

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

United States Steel Corporation Subsidiaries
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☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."
☐ Please have a Stainless representative call on me.

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Position.....
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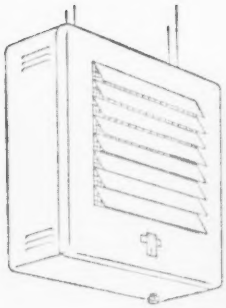
UNITED STATES STEEL



In Unit Heaters
or Fan
Coolers

KLIXON PROTECTORS

KEEP THE HEAT OR COLD ON

BY ELIMINATING MOTOR BURNOUTS

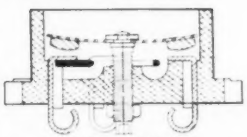
Klixon Protectors built into the motors used in forced air unit heaters and cooling fans help keep the equipment operating dependably by preventing motors from burning out.

These simple foolproof protectors, built in by the motor manufacturer, take into account all the motor destroying factors that cause motors to overheat and burn out, and cut the power "off" should the motor become dangerously overheated. Then when the motor cools they snap the power "on" again. Temporary overloads do not cause nuisance tripouts.

Regardless of the type of motor driven equipment you use or manufacture, always specify Klixon Motor Protectors. Also remember to specify Klixon Protectors in such equipment as transformers, solenoids, adjustable transformers and other electrical equipment.

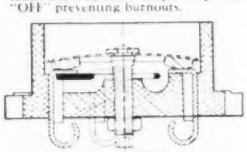
SPENCER THERMOSTAT, *Division of Metals & Controls Corp.*
910 FOREST STREET, ATTLEBORO, MASS.

HERE'S HOW KLIXON PROTECTORS WORK



CLICK . . . IT'S OFF!

When temperature within the equipment reaches danger point, the KLIXON Protector snaps the power "OFF" preventing burnouts.



CLICK . . . IT'S ON!

As soon as equipment cools to safe operating temperature, the KLIXON Protector snaps the power "ON" again automatically or by pushing the manual reset button.

KLIXON
TRADE MARK REG. U.S. PAT. OFF.

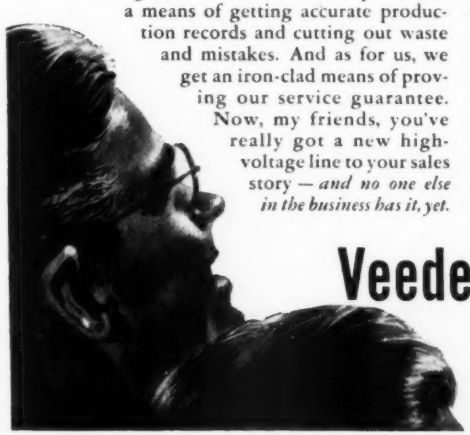
Brother Peddlers! . . .
Meet our New Star Salesman
. . . this built-in VEEDER-ROOT COUNTER*

LISTEN TO THIS SALES MANAGER: "First of the month, this counter goes into all our machines as standard, original equipment. This means *our customers get a new service* from our product—a means of getting accurate production records and cutting out waste and mistakes. And as for us, we get an iron-clad means of proving our service guarantee. Now, my friends, you've really got a new high-voltage line to your sales story—*and no one else in the business has it, yet.* Let's get going!"

That's an example of how "countless" products began to click faster in sales . . . *when they began to count.* For built-in Veeder-Root *Count*rol is a valuable extra service, a distinctive feature that talks business in the language of the toughest customer . . . *in plain, black-and-white figures.*

And these figures can be put to work in endless ways, for a poultry-physician or a map-maker, as the case may be. So why not for *you?* Don't say: "But my product can't count." Give it a chance to speak for itself . . . directly to *us.* Write.

*The Counter shown is a V-R Medium-Size Counter . . . about 4½" long, built into a long list of products to count strokes, turns, pieces, or what have you. It's one of scores of V-R counters shown in the 8-page condensed catalog. *Write for your copy.*



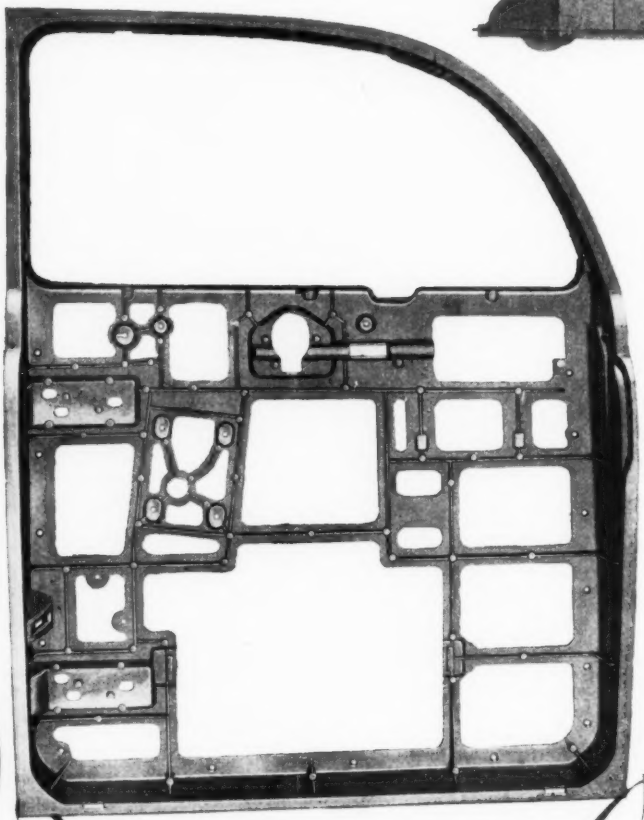
Veeder-Root COUNTERS

VEEDER-ROOT INC., HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3. *In Great Britain:* Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.

DIE CAST AUTO DOOR...

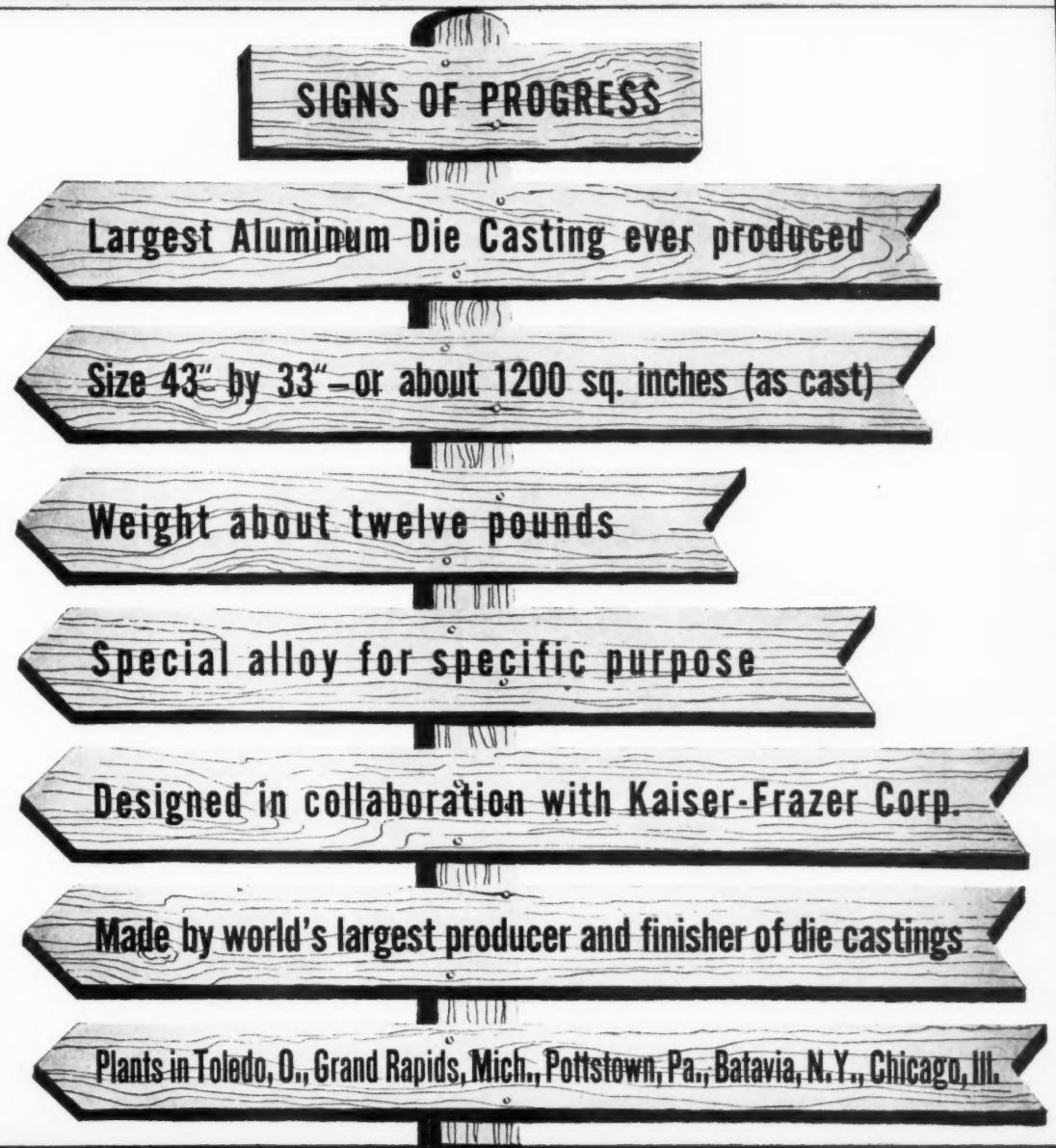
ASSEMBLED



PATENT PENDING

DOEHLER-JARVIS

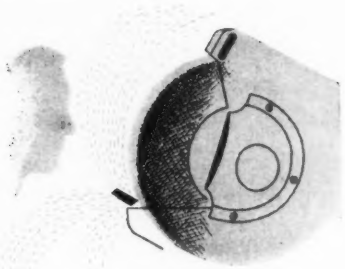
..ANOTHER ACHIEVEMENT


SIGNS OF PROGRESS
Largest Aluminum Die Casting ever produced
Size 43" by 33"—or about 1200 sq. inches (as cast)
Weight about twelve pounds
Special alloy for specific purpose
Designed in collaboration with Kaiser-Frazer Corp.
Made by world's largest producer and finisher of die castings
Plants in Toledo, O., Grand Rapids, Mich., Pottstown, Pa., Batavia, N.Y., Chicago, Ill.

CORPORATION

DOEHLER-JARVIS

they're strong for standardization



Electrical Engineer, machine tool company, says: "I think designers will save time in the long run if they decide, at the start of a job, to use standard motors. We'll eliminate exhaustive engineering tests we used to make on fractionals. With horsepower, service factor, breakdown torque, and starting current all rated on a clear-cut, uniform basis we'll know *in advance* that the motor will do the job."

Chief engineer, portable tool plant, says: "I simplify design when I specify series-motor parts with NEMA standard dimensions for our portable tools. By designing tool housings to take parts conforming to these standards, I simplify case construction, obtain interchangeable motor design, and lower overall costs."

Vice-President, washing machine company, says: "The use of *standard* washing machine motors helps our dealers to give dependable service. With standard motors, the service man can take full advantage of the motor manufacturer's motor-exchange and repair-service plans—take the headaches, and delays, out of motor repairs or replacement. He can be sure that the motor he puts back on the job will perform as it should."

President, electric blower corporation, says: "The big thing about the new fractional-hp motor standardization plan, to me is that we stand a better chance of getting 'off-the-shelf' delivery of motors when they are a big-production item, instead of a special. Also, we eliminate special jigs and fixtures, and the need for making universal mounting bases and adapter plates."

Head of oil burner firm says: "Standardization of motors and parts is most important to our company. Our burners can be made in several sizes and types without changing the motor size or application, even when making improvements and new models. Standardization means lower production and inventory costs for oil burner manufacturer and distributor or dealer."

They use General Electric Standardized FRACTIONAL HORSEPOWER Motors

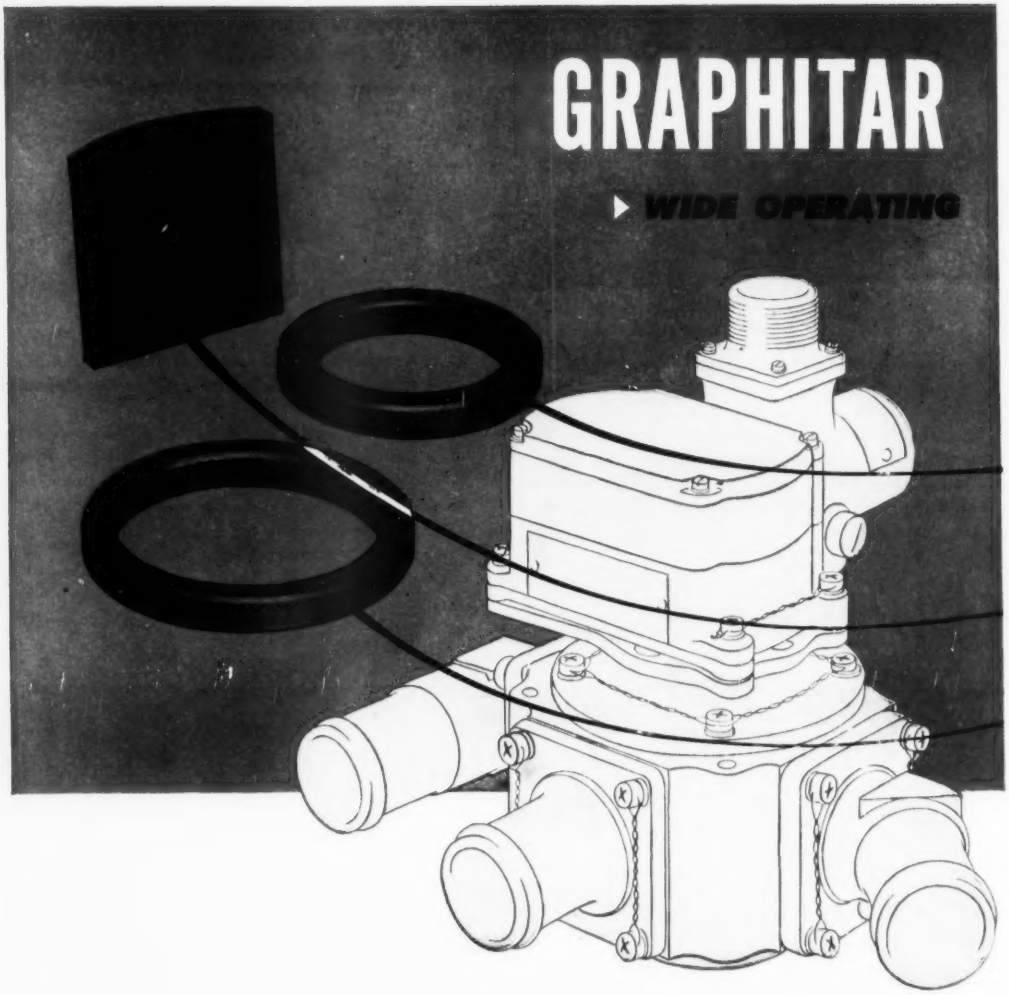
WANT TO SEE whether a switch to standardized General Electric fractional-hp motors will pay off for you? Our engineers will be glad to give you the unvarnished facts. Just drop us a line giving the size, type and special characteristics of the motors you are now using. For general information about fractional-hp motor standards write for Bulletin GES-3565. Apparatus Department, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

700-99

GRAPHITAR

▶ WIDE OPERATING

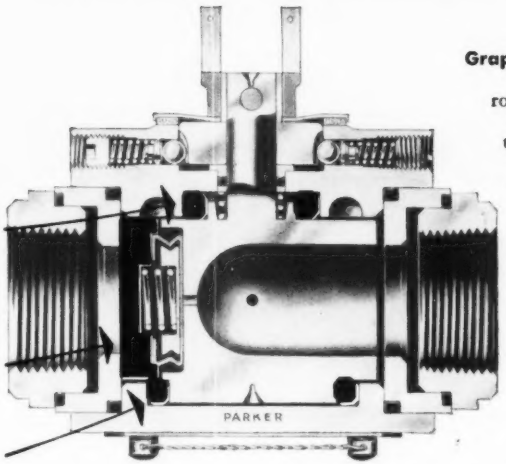


The many unique characteristics of Graphitar make it an invaluable material in many industries. Graphitar is extremely light, mechanically strong, and inexpensive. It finishes to tolerances as close as .0005″ and laps perfectly as a bearing, bushing and seal. Graphitar is unaffected by temperature extremes, and is impervious to strong acids and chemicals. It won't expand, contract, corrode or scale. It needs no lubrication because it is in itself a lubricant. You are invited to send your sketches for study by our engineers. They may be able to suggest Graphitar parts that will solve a mechanical problem for you.

Write for our new 64-page Catalog now ready for mailing.

THE UNITED STATES GRAPHITE COMPANY

GIVES PARKER SELECTOR VALVES RANGE UNDER EXTREME CONDITIONS



Graphitar sealing discs and bearings play important roles in the Parker Aircraft Fuel Selector Valves that insure positive, split-second changes of fuel supply under the most extreme operating conditions. The Graphitar sealing discs constitute ideal lapped port seals for life of the valve. They permit the valve to operate from a range of 0 to 50 psi with low and uniform turning torque, consistent under extreme conditions: wet or dry, new or old, from –65° to 160°F. ▾ ▾ ▾ Two Graphitar bearings permit the valve rotor to be turned smoothly without lubrication. ▾ ▾ ▾ Parker valves control the flow of hydraulic oil, engine oil, water injection systems, large air and vacuum lines as well as aviation gasoline and kerosene. They are applicable as shut-off valves for jet engines in high temperature air lines (up to 450°F.) or as high pressure (500 psi) shut-off valves.

GRAPHITAR

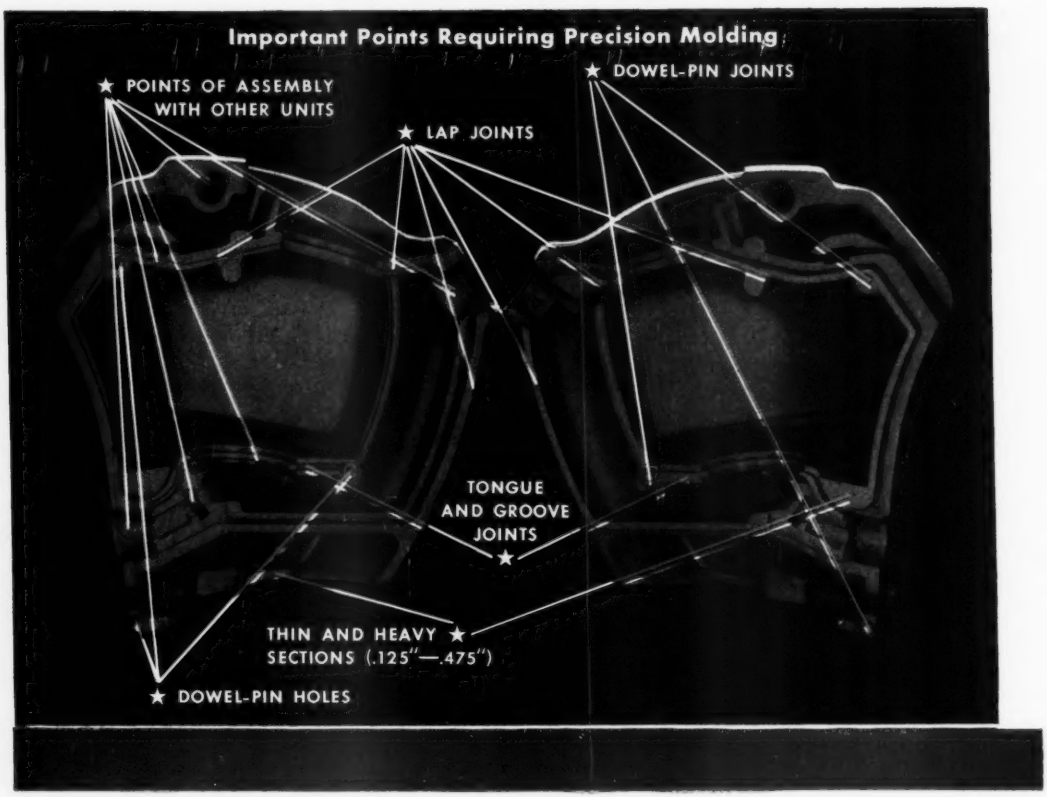
(CARBON-GRAPHITE)

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

NEW PROCTOR STEAM IRON

is tops in plastic

Below are pictured the two halves of the water reservoir for the New Proctor Steam Iron showing the details of its outstanding plastic engineering design.
Product designed by Proctor Electric Company's Engineering Staff, Philadelphia, Pa. in conjunction with Donald E. Dailey, Industrial Designer. *Mold* designed by Proctor Electric Company's Engineering Staff in conjunction with Shaw Insulator Co., Irvington, N. J., molders of the parts.


Important Points Requiring Precision Molding
★ POINTS OF ASSEMBLY WITH OTHER UNITS
★ DOWEL-PIN JOINTS
★ LAP JOINTS
TONGUE AND GROOVE JOINTS
THIN AND HEAVY SECTIONS (.125"—.475")
★ DOWEL-PIN HOLES

engineering!

Intricate design perfectly molded using **Koppers Polystyrene 8**

THE water reservoir for the new Proctor Steam Iron is an unusually skillful accomplishment in plastic engineering. It shows the ingenuity of the designer, the skill of the mold maker and the application of a superior polystyrene.

This application required not one or two, but *eight* special properties—

1. Excellent moldability
2. Ease of flow
3. Low shrinkage
4. Dimensional stability
5. Resistance to heat distortion
6. Light weight
7. Low water absorption
8. Transluscence combined with color

Koppers Polystyrene 8 meets all the requirements with the added advantage of low cost.

The water reservoir is made in three parts —the two shown on the left plus a molded cover. Sections vary in thickness from 0.125" to 0.475". Precision molding makes possible the assembly of close fitting valve parts. Mold design, molding technique and the superior properties of Polystyrene 8 combine to assure accurate fit of tongue and groove joints, lap joints and dowel pin joints. (See illustration.) Parts can be quickly assembled and are cemented together with a specially-developed Polystyrene adhesive.

What is your problem in plastics?

The above example shows how one of the Koppers Plastics filled the exacting requirements of one manufacturer. Our technical service representatives have worked on many such problems and their experience is at your call.

KOPPERS COMPANY, INC.
Chemical Division · Pittsburgh 19, Pa.
Regional Offices: New York, Boston, Chicago and San Francisco

KOPPERS

Koppers Company, Inc.
Chemical Division, Dept. PE-10
Pittsburgh 19, Pa.

Please send me data on Koppers Perfected Plastics.

Name .....
Position .....
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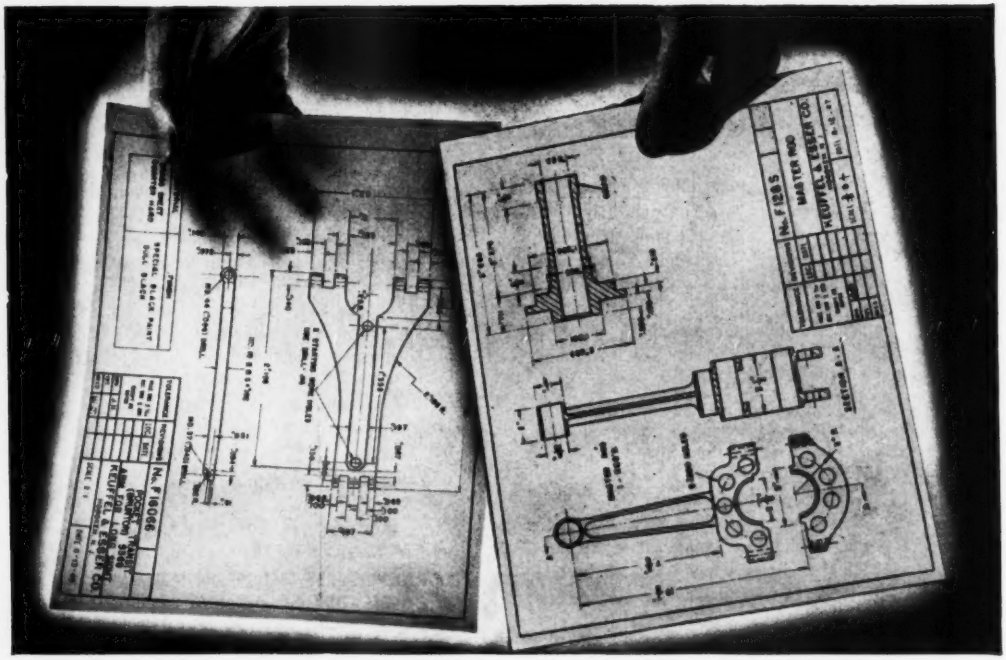
Koppers *Perfected* Plastics

· POLYSTYRENE · CELLULOSE ACETATE · ETHYL CELLULOSE

K+E

partners

For 82 years K&E equipment and materials have been



ONLY HELIOS* DRY DEVELOPING MATERIALS GIVE YOU:

K&E QUALITY. Trusted by draftsmen and engineers for 82 years.

K&E DEPENDABILITY. Your best assurance of consistent results in making positive line prints.

Only when you use dependable materials can you get consistent results in making positive line prints.

To be sure of absolute K&E standards in the color-forming components required for these dry diazo products, we established a new plant where we manufacture HELIOS materials exclusively. We not only control and make the finished materials, but actually manufacture, from the raw materials, the image-forming chemical components as well. Thus HELIOS papers, cloths and films are the product of 82 years of K&E experience and K&E insistence on quality first.

HELIOS dry developed materials cover a wide field of reproduction needs. They consist of opaque papers (black, blue and maroon line) and opaque cloth for working prints, besides transparent papers and cloth and clear and matte films, for intermediate originals (to use instead of originals).

in creating . . .

partners of the draftsman, the engineer and the scientist in shaping the modern world

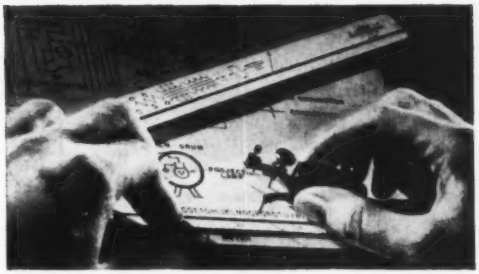
For samples and full information about the HELIOS line and what it can do for you, ask any K&E Dealer or Branch or write us here in Hoboken, N. J.

PARAGON* DRAFTING MACHINES TAKE WASTE MOTION OUT OF DRAWING

The PARAGON Drafting Machine combines T-Square, triangles, protractor and scales, all in one single unit, controlled entirely by one hand. The scales glide into any position on the board. The lightest touch rotates them to the angle desired. You can draw all lines to exact length.

The design of the PARAGON Drafting Machine assures permanent accuracy. The open center arm construction makes it practically impossible to disturb the band tension, which is properly set at the factory and needs no further adjustment.

Let your K&E Dealer or Branch demonstrate this machine or write for full description to Keuffel & Esser Co., Hoboken, N. J.



LEROY* LETTERING AND SYMBOL DRAWING IS UNIFORM AND QUICK

LEROY lettering and symbol drawing need no special skill or training. LEROY equipment offers a wide variety of alphabets and sizes, including Regular Gothic, Reversed, Condensed, Extended and Outline Gothic, Cheltenham, Greek, Isometric alphabets and ellipses, Electrical, Map and Welding symbols.

K&E can make special LEROY templates with your own words, phrases, designs, symbols or trade marks.

Ask your K&E Dealer or any K&E Branch for a demonstration or write to K&E, Hoboken, N. J. for the LEROY Booklet.

*Trade Mark®

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EST. 1867

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CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO

LOS ANGELES • MONTREAL

send for these Free Bulletins for your heating jobs

HEATING LIQUIDS "Built-in" electric heat makes your product a better product because it *puts the heat right where it is wanted!* "Immersion heating" with G-E Calrod* heaters places heat source into the material to be heated . . . for maximum heat transfer with minimum heat losses.

HEATING PIPELINES G-E heating cable and Calrod tubular heaters keep viscous liquids free-flowing and protect pipelines and valves in cold weather . . . a wealth of "how to" information on installation, application and power requirement calculation.

HEATING PROCESS AIR How and where to apply G-E strip, Calrod tubular and fin Calrod heaters for drying, baking, warming, curing and a wide range of industrial processes and equipments.

HEATING SURFACES Whether it's an eighth-inch soldering iron tip or 100 square-feet of platen surface, this bulletin tells you how to calculate your heating requirements . . . which G-E Calrod heater to use and where and how to install it.

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ELECTRIC HEATERS AND HEATING DEVICES New revised catalog lists a wide variety of heaters and devices to meet almost any conceivable heating requirement.

DON'T MISS "HEAT—WHERE YOU WANT IT!" Latest sound slide-film in the *MORE POWER TO AMERICA* series depicts case histories of the above five basic applications of electric heat. Ask your local power company representative or contact the nearest G-E Sales Office.

BEFORE you design your electrically heated machinery or equipment . . .

BEFORE you convert existing installations . . . consult the G-E apparatus salesman who regularly calls on you or a G-E Industrial Heating Specialist . . . his recommendations will pay you real dividends in terms of more efficient heating and better designs. *Reg. U.S. Pat. Off.

GENERAL ELECTRIC

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check Check those publications (above) you want for your particular applications and mail today to:

Apparatus Dept., Sect. 720-8,
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For the information of those who use

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● From these "Gilt-Edge" distributors located throughout America, SHELBY SEAMLESS STEEL TUBING is available. From the one most convenient to you, you will be able to get not only what you need from his complete stock, but you will also find that he knows mechanical tubing from every angle and is keenly interested in helping you solve your tubing problems. You can rely on him in all matters concerning mechanical tubing and its applications, for in reputation, experience, and warehousing facilities, Shelby distributors are "tops" in the industry.

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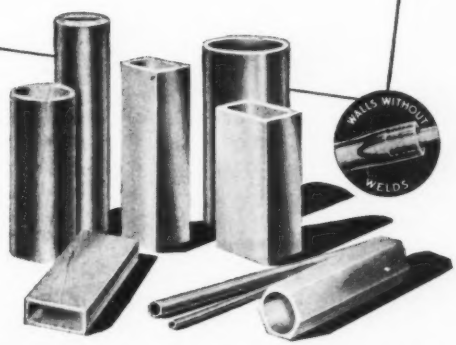

MADE BY THE WORLD'S LARGEST MANUFACTURER of steel tubular products, SHELBY SEAMLESS STEEL TUBING is available in round, square, rectangular, and other special shapes, in any commercial size—from ⅜ to 10¾ inches OD, and in wall thicknesses from .035 inch cold drawn . . . and in a wide range of steel grades and anneals.

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COLUMBIA STEEL COMPANY, SAN FRANCISCO
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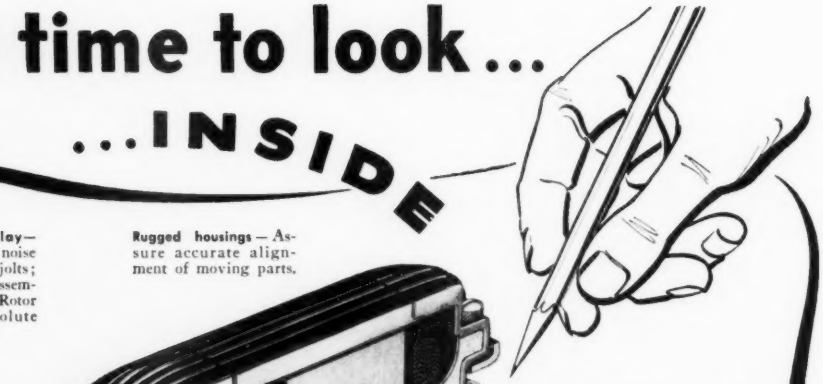
SHELBY SEAMLESS STEEL TUBING

UNITED STATES STEEL

Take time to look...

...INSIDE



Controlled end play—Takes shock and noise out of end play jolts; allows precision assembly into your unit. Rotor remains at absolute magnetic center.

Rugged housings—Assure accurate alignment of moving parts.

H.P. rated at full load—Motors individually tested to assure specified h.p. rating.

Super-safe lubrication—Extra large reservoirs with recirculation of lubricant.

Flush surface rotors—For quiet, smooth, balanced operation.

Individually fitted bearings—Fitted to the shaft at .0001" tolerance, at clearance of .0005".

Accurate alignment—Concentric air gap is assured by machined frame and self-aligning bearings.

Precision field construction—Machine wound, varnish baked coils are highly resistant to oil and humidity.

Redmond MICROMOTORS

There's a lot of difference in today's electric motors.

Outwardly, they all conform pretty much to a general pattern for each particular type, size and purpose.

But the experienced buyer of motors knows that the *real character*—the *genuine worth*—of a motor lies beneath the outer shell.

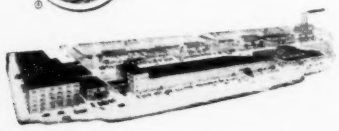
That's why Redmond advises, "Take Time to Look Inside."

For Redmond Micromotors look better, the more they are examined, the more they are compared. Look inside a Redmond Micromotor and you will find a list of features unmatched by any other make.

Look inside and you will learn why Redmond Micromotors give you the smoothest, quietest, longest-lasting service you've ever known in an electric motor.

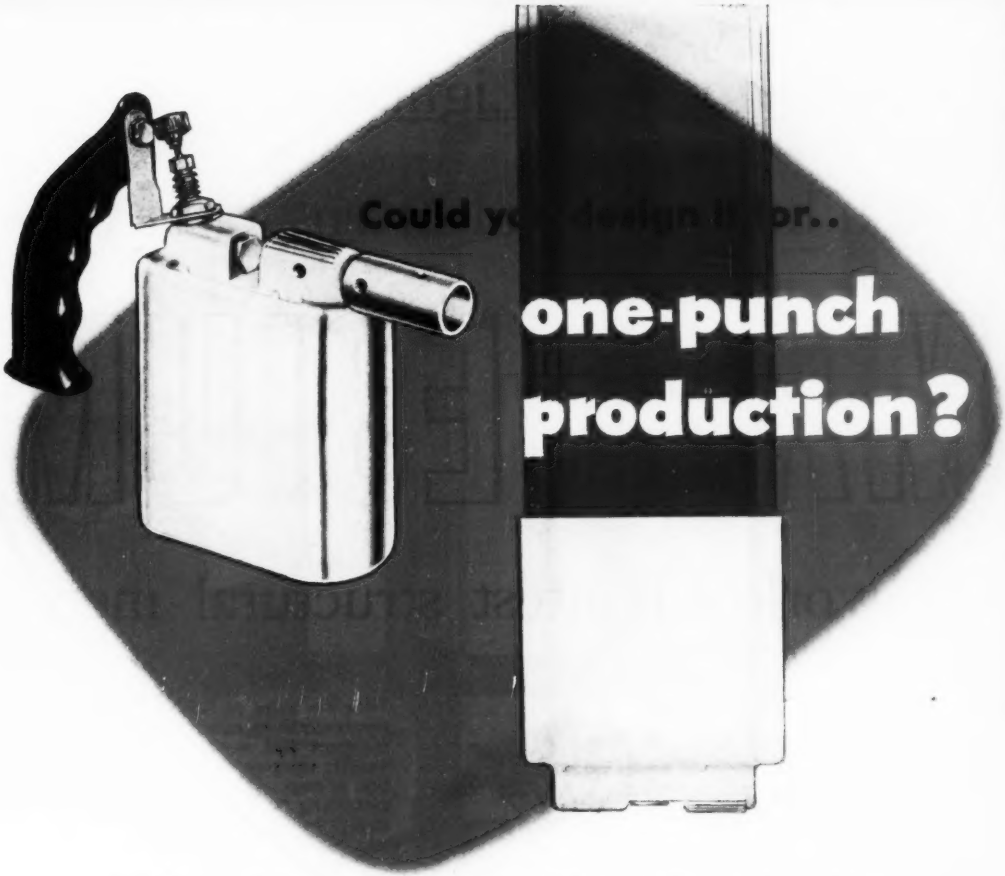
Yes, take time to Look Inside. You'll *see* the difference!

150 standard models, 25 types, up to 1/10th h.p. A.C. and D.C. Illustrated is the type "Y" A.C. Micromotor.



Redmond COMPANY, INC., OWOSSO, MICHIGAN

Offices in: New York, Chicago, Los Angeles, Dallas



Alcoa's Impact Extrusion process formed this blowtorch housing—charging well, torch tube housing, handle and valve mounting—with just one punch!

Impact extrusions can often give you any symmetrical shape at substantially lower cost than spinning, stamping, drawing or machining; widest choice of finishes, too—from as-delivered to patented Alumilite. You get all these in addition to Alcoa Aluminum's light weight, strength, corrosion resistance, handsome appearance.

Get the whole story about how this versatile process can give your product more sales appeal at lower cost! Call your nearby Alcoa sales office. Or write for your free copy of "Alcoa Aluminum Impact Extrusions" to ALUMINUM COMPANY OF AMERICA, 692K Gulf Bldg., Pittsburgh 19, Pa.

ALCOA *Aluminum* **IMPACT EXTRUSIONS**

ALCOA ALUMINUM

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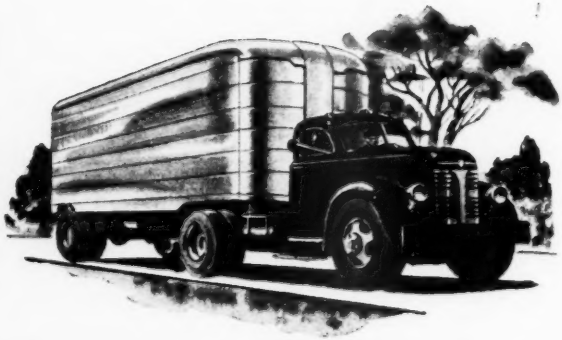
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

"Only Magnesium-Light is light enough"

You'll hear this said often about Dow

MAGNESIUM

the world's lightest structural metal!



With the value of lightness emphasized by constantly rising costs, operators in the motor transport field want more than just lightweight equipment—they want equipment that is *magnesium-light*. These men who use everything from small panel trucks to huge trailers know that only with magnesium can maximum lightness be achieved.

Magnesium is strong and durable and yet is a full one-third lighter than any other structural metal. This bonus—this premium of one-third greater lightness—makes possible significant weight savings which are immediately reflected in increased payload and decreased operating and maintenance costs. A properly designed magnesium body is frequently 20-25% lighter than the same size body built with other light metals.

This is just one of the fields where magnesium increases efficiency by cutting dead weight to a minimum. It will pay you to investigate magnesium lightness when designing your product. For case studies on successful uses of magnesium, send for "How Magnesium Pays."

Get maximum weight reduction—
Use Magnesium Extrusions

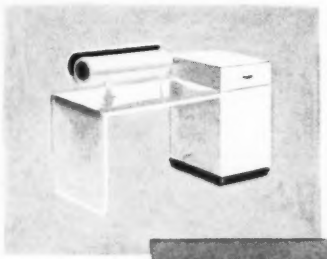
Magnesium extrusions can give you significant weight reductions without the loss of needed strength and rigidity. Often, the use of magnesium extrusions tailored to your particular needs will cut manufacturing costs by eliminating the necessity of forming or fabricating from standard shapes. They are competitively priced and available in rods, bars, and tubes as well as structural shapes conforming closely to American Standard Sections.

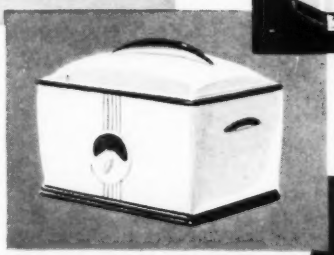
Lighter Products Sell—make your product Magnesium Light!

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston
San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

Weirzin





TAKES PAINT EASILY— HOLDS IT FAST

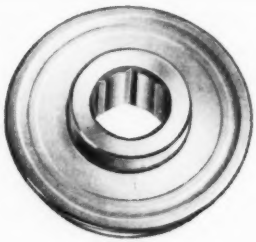
Paint stays put—and so do enamels, lacquers, varnishes and lithographic inks—on products made of durable Weirzin as supplied direct from Weirton in coils or cut lengths. Paint and other finishes, once applied, are there to stay—safe from the marring effects of underfilm corrosion, which just cannot occur in Weirzin. Its tight malleable zinc coating, electrolytically applied, is integrally bonded to the steel—to remain intact through manufacturing operations, and under all conditions of temperature and humidity.

WEIRTON STEEL CO.

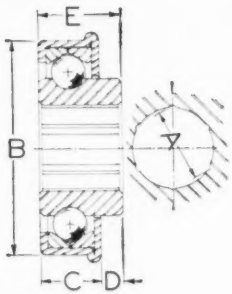
WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pa.*

"Commercial" Ball Bearing Data...#4 of a Series



TYPE "A" UNGROUND FLANGED BALL BEARINGS WITH HEX BORES



APPLICATIONS: Replaces costly precision bearings whenever loads and speeds permit; eliminates expensive machining and assembly time now required for bushings and plain sleeve bearings.

In almost every type of conveyor calling for an easily mounted bearing with positive shaft connection.

FEATURES: HEX BORE provides sure shaft mounting with *no* slippage.

FLANGED OUTER RING eliminates counterboring when locating bearing. Especially easy to mount in tubing.

CARBURIZED RACE RINGS—hardened and tempered, with smoothly finished ball tracks.

DIMENSIONS IN INCHES—RATINGS IN POUNDS

Bearing No.	A Hex Bore	B Outside Diameter +.002" −.002"	C Width	D Extension	E Width	F Flange Diameter	Balls No.	Balls Size	Load Rating at 600 RPM
CS 3109	3/8	1 1/8	3/8	1/8	1/2	1 1/4	15	5/32	60
CS 3110	25/64	1.146	3/8	1/4	5/8	1 9/32	16	5/32	65
CS 3111	3/8	1 3/8	7/16	3/16	3/4	1 17/32	10	1/4	105
CS 3152	7/16	1 1/4	3/8	5/32	17/32	1 11/32	13	7/16	76
CS 3100	7/16	1 1/2	7/16	3/16	1/2	1 39/64	11	7/16	130
CS 3101	7/16	1 1/2	7/16	1/4	11/16	1 39/64	12	1/4	125
CS 3131	7/16	1 1/2	7/16	9/64	37/64	1 11/16	12	1/4	125
CS 3119	1/2	1 1/2	7/16	1/4	11/16	1 11/16	12	1/4	125
CS 3120	9/16	1 9/16	7/16	1/4	11/16	1 23/32	13	1/4	135
CS 3121	5/8	1 3/4	9/16	1/4	12/16	1 25/32	14	1/4	145
CS 3122	11/16	1 7/8	1/2	1/4	3/4	2 1/32	15	1/4	155
CS 3123	3/4	2	1/2	1/4	3/4	2 3/16	17	1/4	175
CS 3108	9/16	2 3/64	5/8	1/4	7/8	2 1/4	14	5/16	230
CS 3143	5/8	2 5/16	5/8	1/4	7/8	2 15/32	13	3/8	300

OUR NEW CATALOG No. 11

This 40-page book contains load tables and dimension data on all Schatz "Commercial" Ball Bearings. You'll also find information on the Schatz Special Bearing Engineering Service, which has helped many manufacturers solve their bearing problems by adapting or designing a special low-cost ball bearing to meet individual requirements. Write for your copy today.

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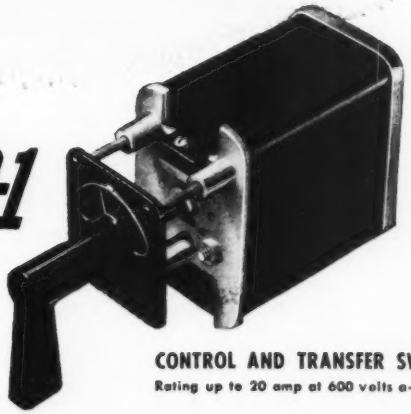

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The Spotlight's On

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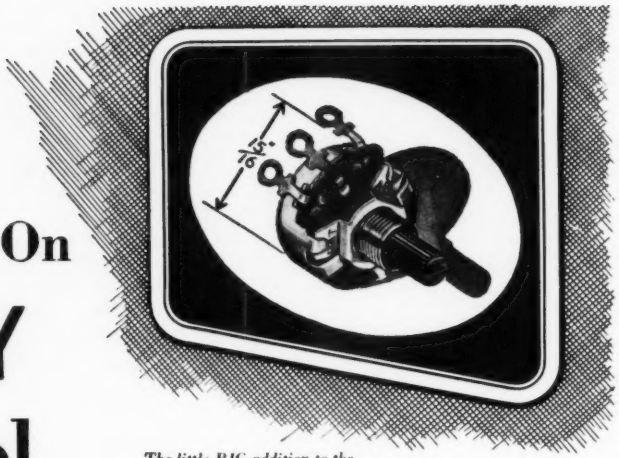
MALLORY Midgetrol



The little BIG addition to the Mallory Line of Television Controls.

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Don't be deceived by its compact size. It's all Mallory through and through. For instance: Shaft is completely insulated from chassis. Good for higher voltage applications—can't get a shock. The insulated shaft is knurled for easy adjustment—has screw-driver slot for back panel applications. Thoroughly tested, the Mallory Midgetrol has come through with flying colors for television applications.

The Mallory Midgetrol is typical of Mallory superiority in controls. Today, Mallory has a control, carbon or wire-wound, required for any specific usage, for every television application.

The dependability of today's television receivers which is responsible for the great public demand has as one of its bases the precision performance built into Mallory controls by special skills, long experience and devotion to quality ideals.

And with all this superiority, Mallory offers service—quick delivery for both standard and special applications—and low price.

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4. For linearity
5. For centering picture on tube, horizontal or vertical
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7. For horizontal and vertical "hold" controls
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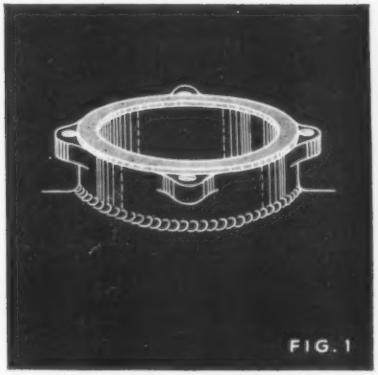
FIG. 1

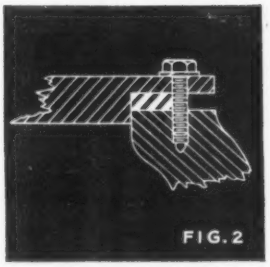
FIG. 2

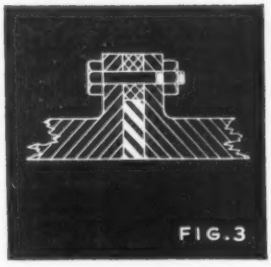
FIG. 3

Gaskets with projections around bolt holes often can be redesigned to eliminate such ears and still provide a tight seal. Gasket costs ordinarily can be cut in this way wherever it is not necessary to seal around bolts or prevent moisture accumulation between flanges.

Ears can be removed in almost every case where they are used simply to hold a gasket in position. The resulting unrestrained gasket will remain firmly seated if it is made from a material that will deform in the direction of the load without appreciable sideflow. Armstrong's Cork-and-Rubber Compositions meet this requirement. Because these compositions are truly compressible, they have no tendency to creep. In addition, their exposed cork particles provide surface friction that further inhibits lateral movement.

Compressible gaskets stripped of ears or other dispensable projections obviously are less expensive to manufacture. Even greater savings often are possible if the resulting shape is circular. Then gaskets can be lathe-cut automatically from tubes—with almost no waste.

The hand hole cover gasket in figure 1 illustrates a typical application where Armstrong's Cork-and-Rubber Gaskets reduce sealing costs by eliminating the need for ears. Accurate positioning is insured by making the O.D. of the gasket tangent to the edge of the bolt holes.

Another application is the transfer case flange shown in figure 2. Here the cork-and-rubber gasket provides an effective low-cost seal. Its true compressibility prevents creep and its solvent resistance is comparable to the straight synthetic it replaced.

In figure 3, cost-saving rings are used in conjunction with a metal shim to insure positive gasket alignment and prevent excessive gasket compression.

Removing ears is only one of the ways that you can reduce sealing costs with Armstrong's Cork-and-Rubber. We suggest that you ask your Armstrong representative how these versatile materials can help you.

Send for this Gasket Handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

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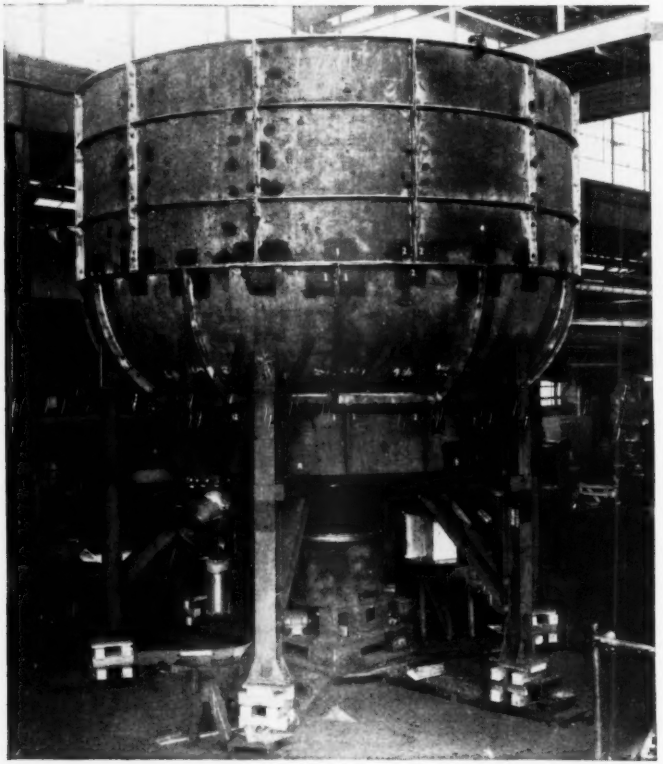

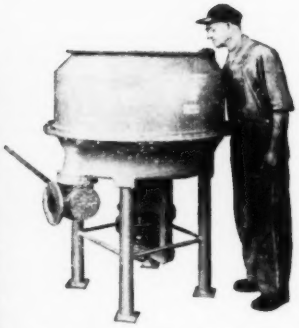

Laboratory Hydrapulper by Shartle Bros.; its 3-foot tub is Stainless-Clad Steel.

This Shartle Bros. Hydrapulper has an 18-foot tub made of Type 304 Stainless-Clad Steel. Erected at the Shartle Plant for checking and match-marking of parts prior to shipment to the mill, this Hydrapulper was shipped knocked-down, and assembled in the paper mill by welding.

No metallic contamination of materials processed in these Hydrapulpers! Only stainless steel—highly resistant to corrosive attack and abrasion—comes in contact with them. That stainless steel is permanently bonded to steel backing plate, giving the necessary structural stiffness and strength.

Lukens furnishes Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels to builders of equipment supplying your industry. Thus, those manufacturers are able to give you products offering all the advantages of these *solid* corrosion-resistant metals at the lower cost of *clad* steels.

Claddings are usually 10% or 20% of total plate thickness, depending upon the service on which they are to be used. All Lukens Clad Steels are available in the extra-smooth sodium hydride finish, making them extra easy to keep clean.

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Ask your supplier to quote on equipment made of Lukens Clad Steels. And for more information on these materials, write for Bulletin 470. Lukens Steel Company, 405 Lukens Bldg., Coatesville, Pennsylvania.

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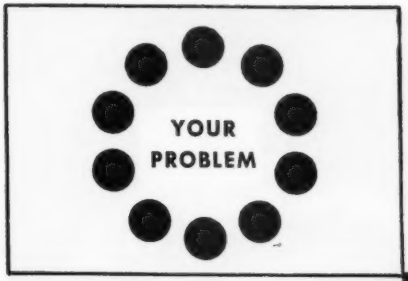

The Monsanto Plastics Technical Council—ten men, each a plastics specialist in his own field. Their combined knowledge and experience blanket plastics and dozens of other industries. They offer you *ten approaches* to any given problem.

why not use TEN approaches to ONE problem?

The other day, one of our friends tossed us a problem he had in materials.

"Can you suggest," he asked, "a plastic for a graduated scale on an instrument used in biological laboratories? It must have exceptional dimensional stability . . . good transparency . . . withstand occasional water temperatures up to 190° F . . . and be resistant to phosphoric acid, glycerine, and weak alcohol."

We passed his question on to Monsanto's unique board of ten plastics experts . . . The Monsanto Plastics Technical Council . . . a group of engineers with years of individual experience and specialized knowledge covering the many phases of the complex plastics industry (and several dozen other industries, too).

They came right up with the answer. "Yes, Monsanto produces a plastic that will fit your requirements. It's Lustrex . . . Monsanto's polystyrene . . . which has the following properties of interest to you . . ." And so on.

Then there was a letter from a v. p., wanting to substitute a laminated plastic beam for the wooden timber now used to carry the pick-up shoe on subway cars. He told us the beam must withstand extremes of temperatures, and rapid temperature *changes*, plus good weatherability under rain, sleet and ice conditions.

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Whatever your product or industry, why not put ten expert approaches to work on your materials questions today? Pose the Technical Council any plastics problem you have, simple or complex. Let it examine any ideas you have in mind — *before* you begin costly production.

There's no cost, no obligation. The Council is just another Monsanto service to the plastics industry.

Lustrex, Resinox: Reg. U. S. Pat. Off.

Monsanto Invites You to send in your questions . . . problems in materials, methods, techniques, costs, or styling. We'll be glad to help you solve them! You may also want our free booklet, "Ten Heads Are Better Than One," describing the Technical Council and how it operates. The coupon is for your convenience.

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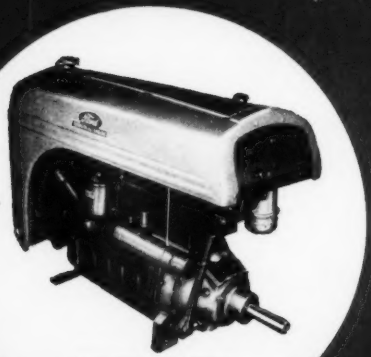

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OIL SEALING UNDER SEVERE MISALIGNMENTS

In some heavy stationary machines, such as found in paper mills and similar industries, where cycle of operation is changed frequently, special consideration must be given to bearing protection. In order to employ friction-free bearings it is necessary to provide oil seals which insure lubricant retention under extreme eccentricities and misalignments.

Figure 2
Compact design of Convoluted Flex-type seal.

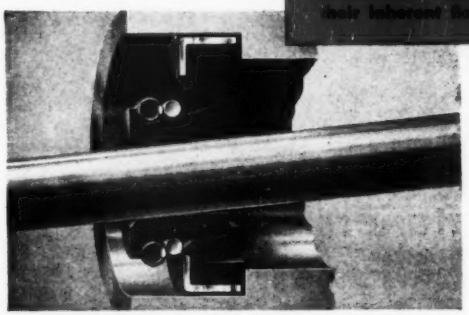

Figure 1
How Convoluted Flex-type seal with extended lip follows misaligned shaft.

LONG, FLEXIBLE SEALING LIP

A National Syntech Oil Seal, having an extra long, flexible sealing lip, is currently being employed in mechanisms of this kind. This special seal, similar to the Convoluted Flex-type (Fig. 1), permits a shaft movement off center as much as .060" while under continuous operation, or much greater under static conditions, without loss of lubricant from the bearing. This particular seal employs two tensioning springs on the sealing lip, One is a conventional coil spring while the other is a single-ring type spring, designed to relieve strain from the coil.

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National engineers have been able to solve many difficult sealing problems through the use of Syntech sealing members. In the Special Convoluted Flex-type seal (Fig. 2), the same design principle is employed in a more compact manner for limited space applications. In many cases oil seals, whether of special design or taken from National's broad group of stock numbers, have been found more efficient and more economical than complicated packing systems formerly utilized. Further information will be gladly provided. Please contact the nearest National Oil Seal office.

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**Syntech is the registered trademark for the National synthetic rubber compound.*

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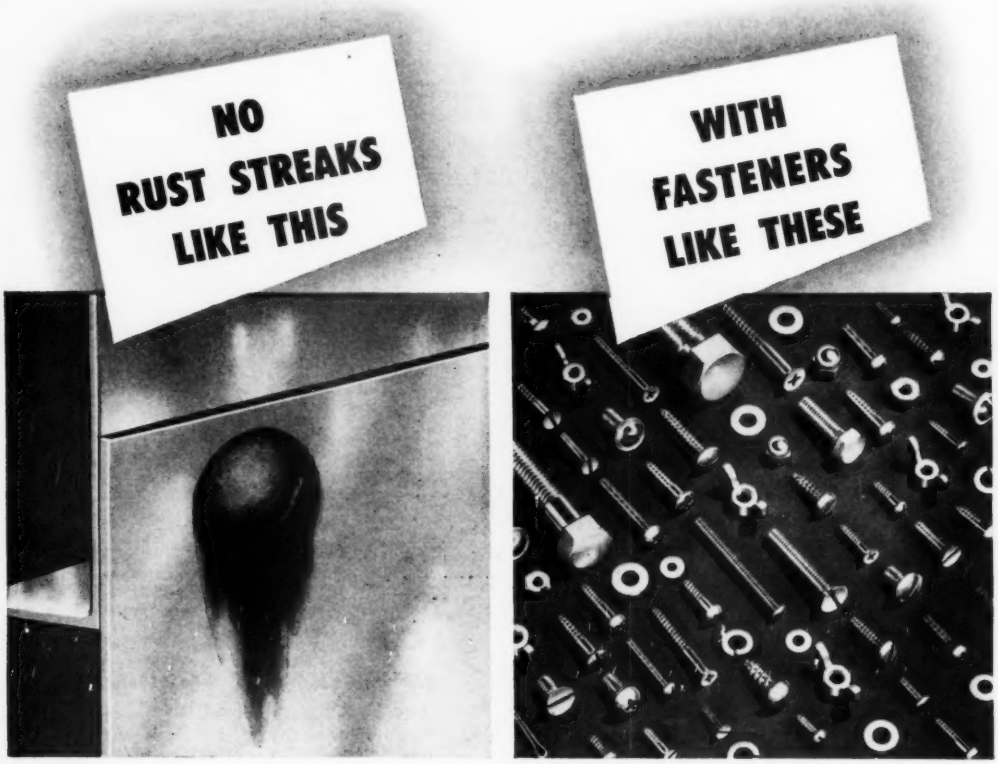

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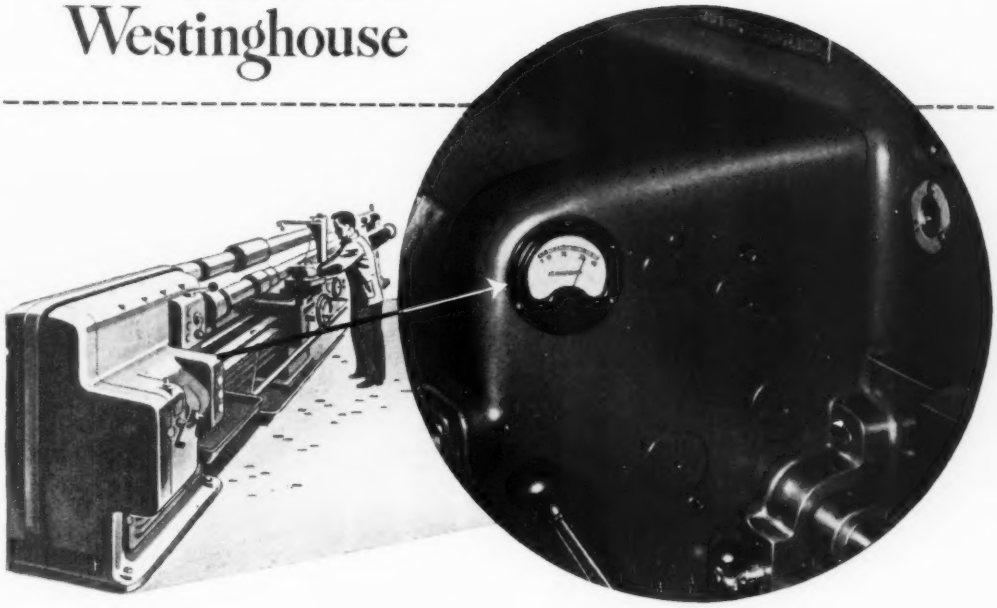

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Typical of the important Meehanite parts are the following:

1. Curb and Floor Base.
2. Legs.
3. Motor Bracket.
4. Basket Comb.
5. Sheave and Brake Drum.
6. Bearing Housings.

The variety of these parts and their important functions are indicative of proper design analysis and the recognition that only through the assurance of quality castings can all service requirements be met.

Your equipment can take advantage of the uniformity and dependability built into Meehanite castings.

For further information write for the Meehanite Handbook, 67 pages of important engineering data, to any of the foundries listed.

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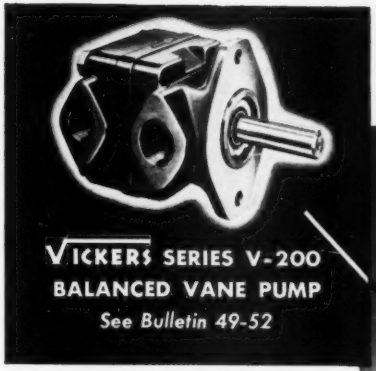
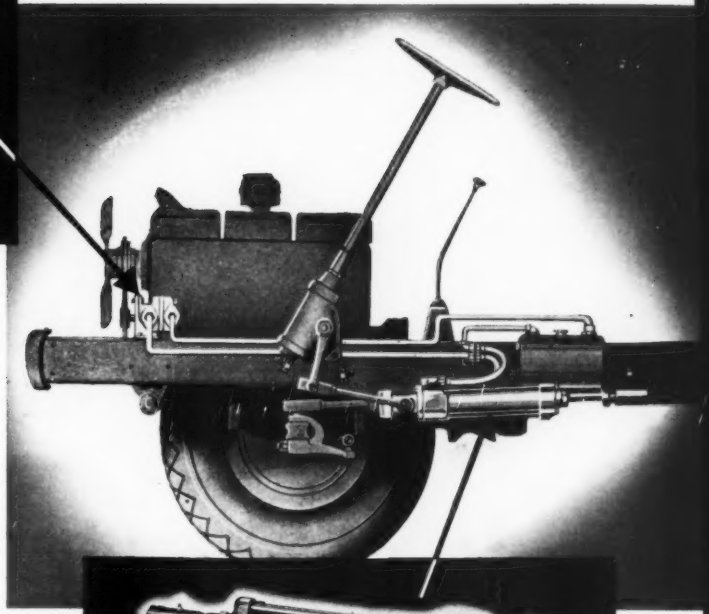
Meehanite® NEW ROCHELLE, N. Y.

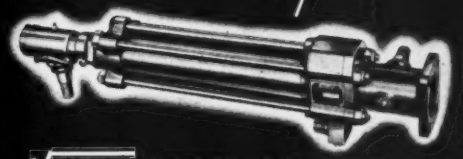
VICKERS Hydraulic Steering System COSTS YOU 20% Less THAN PREWAR



VICKERS SERIES V-200
BALANCED VANE PUMP
See Bulletin 49-52



At the current low prices, your new models should offer the added sales advantages made possible by VICKERS Steering System



VICKERS HYDRAULIC STEERING BOOSTER with integral overload relief valve . . . *See Bulletin 47-30a*

Improved design, better tooling and production methods of the past 10 years have resulted in a more than 20% price reduction in the Vickers Hydraulic Power Steering System. This saving greatly broadens the application possibilities of the Vickers Steering System.

Important among the many advantages of the Vickers Steering System are safety, effortless steering, adaptability and operator satisfaction. The resulting substantial customer acceptance and preference for Vickers Hydraulic Power Steering System is evident from its specification as original equipment by an increasing number of mobile equipment builders and operators alike.

3987

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1454 OAKMAN BLVD. • DETROIT 32, MICHIGAN

Application Engineering Offices:

ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • LOS ANGELES • PHILADELPHIA • PITTSBURGH • ROCHESTER • ROCKFORD ST. LOUIS • SEATTLE • SUMMIT, N.J. • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

THERE'S NO QUESTION ABOUT THE TENSION

For the "know-how" to obtain and hold correct spring tension is Gibson's long suit! Every safeguard in design, toolmaking, production, heat-treating and finishing is aimed at one result—uniform, long-lived spring action. We'll be glad to relieve the "tension" in your plans for mechanical motion. Gibson puts it where it belongs—in the spring.

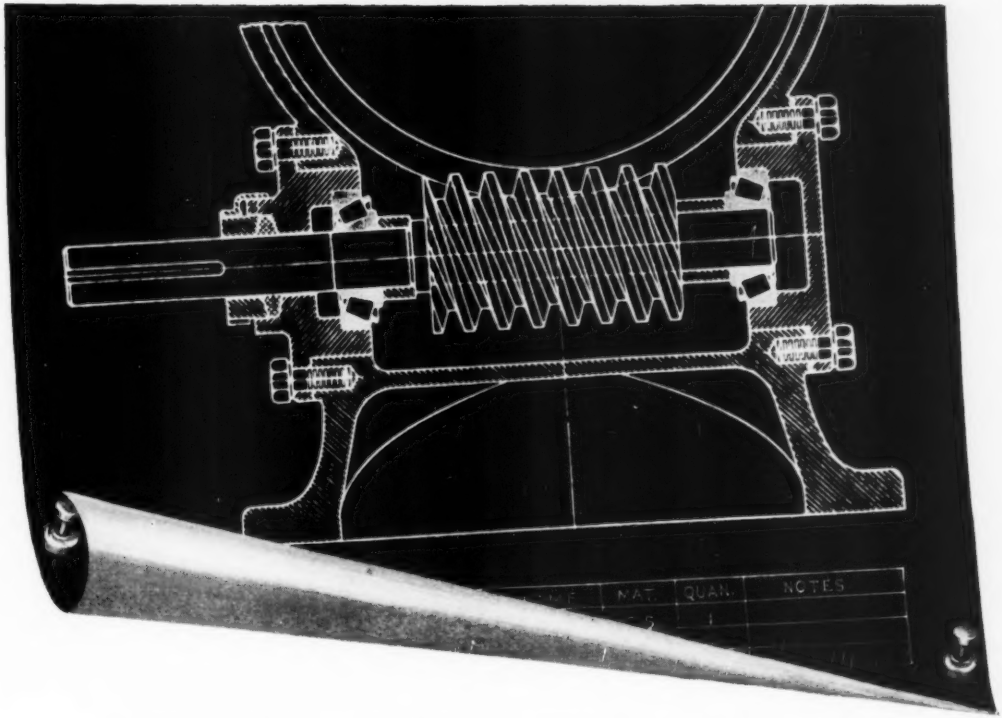
SMOOTH ACTING

GIBSON-SPRINGS

CLIPS • SMALL STAMPINGS
CLAMPS • WIRE FORMS

The William D. Gibson Co.

DIVISION OF ASSOCIATED SPRING CORP.
1800 CLYBOURN AVE., CHICAGO 14, ILL.



How to make your product do more work with less play

YOUR product does its job more efficiently and lasts longer when every rotating shaft is mounted on Timken® tapered roller bearings.

Timken bearings hold shafts in true alignment, prevent shaft deflection and end-play, keep gears meshing smoothly. Due to their tapered construction, Timken tapered roller bearings take any combination of radial and thrust loads. Special thrust bearings or washers are unnecessary. Design can be simplified—space saved.

Timken bearings are manufactured to extreme precision. Their true rolling motion practically eliminates friction on moving parts. Line contact between the rolls and races provides maximum load-carrying capacity.

Made of the finest steel ever developed for tapered roller bearings—Timken fine alloy steel—Timken bearings last the life of the machine in which they are used.

No other bearing can bring you *all* the advantages you get with Timken bearings—backed by fifty years of research and development. Make them standard in all the machinery you buy or build. And look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

50th birthday of the company whose products you know by the trade-mark: TIMKEN

TIMKEN 1899 50 1949 YEARS

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ◯ NOT JUST A ROLLER ⊂ THE TIMKEN TAPERED ROLLER ⊃ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

Let OSTUCO'S "Single Source" Operation Cut Your Tubing Costs

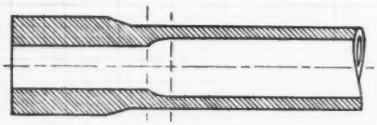
By performing all three basic operations — manufacturing, shaping, and fabricating— at one plant location, OSTUCO greatly reduces the cost of both Seamless and Electric Resistance Welded Steel Tubing for a wide variety of uses.

Unnecessary freight charges are eliminated along with duplicate sets of instructions and similar red tape. No time is lost in shipping materials from one supplier to another. Speedy deliveries permit you to operate with lower inventories. And best of all, highest quality is assured through unified control of production.

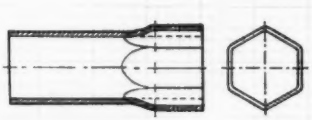
OSTUCO procures the raw materials . . . produces the tubing in a broad range of sizes and shapes . . . meets your most exacting requirements in bending, reducing, expanding, flanging, upsetting, in fact all types of forging and fabricating operations. We are also in a position to supply the tubes painted or plated.

Find out more about how OSTUCO's complete modern facilities and long experience can save you money. Write direct or to our nearest Sales Office for new free booklet "Fabricating and Forging Steel Tubing."

TAPERING



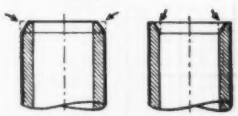
EXTERNAL-INTERNAL UPSETTING



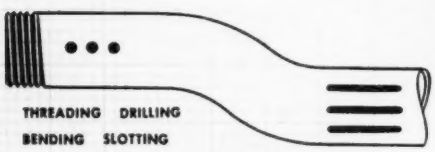
SHAPING

VARIABLE WALLS

JUST A FEW OF THE THINGS OSTUCO CAN DO WITH TUBING



OUTSIDE CHAMFER INSIDE CHAMFER



THREADING DRILLING
BENDING SLOTTING

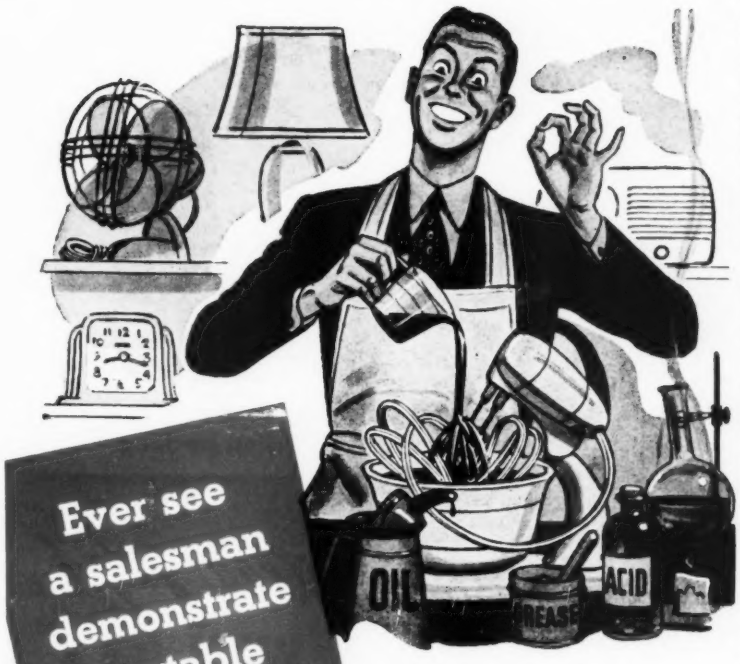
OSTUCO

THE OHIO SEAMLESS TUBE COMPANY

Manufacturers and Fabricators of Seamless and Electric-Welded Steel Tubing
Plant and General Offices: SHELBY 7, OHIO

Sales Offices: CHICAGO, Civic Opera Bldg., 20 North Wacker Dr. • CLEVELAND, 1328 Citizens Bldg. • DAYTON, 1517 E. Third Street • DETROIT, 2857 E. Grand Blvd. • HOUSTON, 6833 Avenue W, Central Park • LOS ANGELES, Suite 300-170, So. Beverly Drive, Beverly Hills • MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • ST. LOUIS, 1230 North Main St. • SEATTLE, 3104 Smith Tower • SYRACUSE, 501 Roberts Ave.
CANADIAN REPRESENTATIVE: Railway & Power Corp., Ltd., NEW GLASGOW, MONTREAL, NORANDA, NORTH BAY, TORONTO, HAMILTON, WINDSOR, WINNIPEG, EDMONTON, VANCOUVER

Build more "SELL" into your product with G-E Wires and Cables



The salesman may not even mention the cord when he demonstrates your product, but the customer soon finds out about the quality of the cord you use.

Tough, good-looking General Electric Flamenol® cords mean continuous, dependable service under severe operating conditions. Their light weight and flexibility make them easy to handle. The thermoplastic jacket resists water, oils, acids, alkalies, and sunlight, and in addition gives the cord a smooth, glossy finish that cleans with a quick wipe. Flamenol cords . . . with the confidence-inspiring General Electric name . . . provide a strong link in a *quality* sales story.

You can get Flamenol cords in a wide range of sizes — from Type SRT for the really tough industrial applications, to extra-flexible rip cord for wiring small devices. You'll like the way Flamenol cord strips clean for fast connecting . . . your customers will like the flexibility, neat appearance, and extra wear they get from G-E Flamenol cords.

Why not give *your* products the added advantage of hard-wearing General Electric Flamenol cords? To get more information on these popular cords, write to Section W33-1067, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

New heater cord. Nothing to fray . . . at least ten times the abrasion resistance of braided cords . . . smooth jacket that's highly resistant to water, oil, and grease . . . sound like a heater cord you've been waiting for? It's Preen-X, the all-new heater cord by General Electric, and it's available now! Write for a free sample—see for yourself what a really new idea in heater cords Preen-X is.

Portable cords. In addition to famous Flamenol portable cords, General Electric also makes a complete line of neoprene and rubber portable cords for all purposes. Whatever the application, whatever the operating condition, you can select a suitable cord from this really complete General Electric line.

Deltabeston® hook-up wires can meet your most exacting standards for resistance to heat, cold, moisture, fumes, and flame. Rigidly tested in the laboratory and proved in use, these lightweight, small-diameter, extremely flexible wires are recommended for radio, electronic, and communication equipment. See your General Electric wire and cable representative for complete information.

Flamenol wires for machine control circuits are built to stand up under oils, acids, and dampness. These tough wires are built for easy stripping — color-coded for easy circuit tracing. Every manufacturing step is carefully controlled to produce a uniform, high-quality wire that will stand up under severe conditions.

WIRES AND CABLES

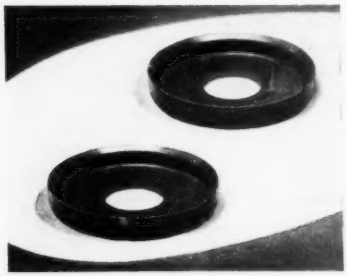
GENERAL ELECTRIC

TWO WAYS TO PACK PISTONS:

Johns-Manville
Moulded Packing Cups

Conventional
type piston packing

— Which does the better job?



RECOMMENDED FOR PISTONS IN

Reciprocating Pumps	Compressors
Hydraulic Lifts	Governors
Hydraulic Jacks	Power Shovels
Hydraulic Presses	Grease Guns
Drilling & Boring Machinery	Air Chucks
Air Brake Cylinders	Grinders

Valves (hydraulic or air operated)

BOTH THE PACKINGS shown on these two pistons will do a job. But the piston on the left will operate more efficiently and more economically because it is designed for Johns-Manville Moulded Packing Cups.

Design engineers are expressing a growing preference for these custom-made cups for two reasons: (1) They practically eliminate slippage past the piston. (2) They require less frequent replacement in service.

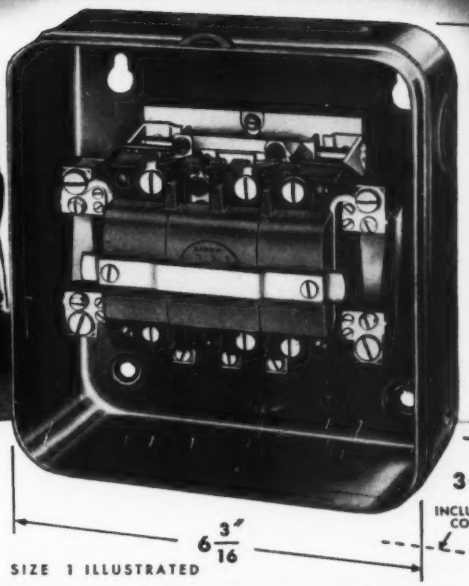
Johns-Manville Moulded Packing Cups operate like this: Each cup is designed with a flexible lip, which, under discharge pressure, forms a tight seal. On the reverse stroke, the lip relaxes. This action, plus their precise fit, lowers friction and wear on liners and reduces the amount of power required for the stroke

Wherever Johns-Manville Packing Cups have been used—against water, oil, air, and other liquids and gases—they have proved to be a good investment by increasing efficiency and lowering operating costs. If you design or manufacture any of the equipment listed at left, write for further information about these custom-made cups. Address Johns-Manville, Box 290, New York 16, N. Y.

JM

Johns-Manville *Packings and Gaskets*

EASY *to Wire to Service*



SIZE 1 ILLUSTRATED

ARROW AH HART

NEW "RA" SIZE 1 MAGNETIC STARTER

THE SMALLEST STARTER ON THE MARKET

AVAILABLE IN LOCAL AND REMOTE CONTROL OR SELECTOR SWITCH TYPES

Working electricians — installation and maintenance men — have approved the new Arrow-Hart "RA" Magnetic Starter. Its new design makes wiring easier — straight through all the way — provides roomier wiring space in smaller enclosures and requires less mounting space when installed on panels.

Servicing is easy, too. All terminals and contacts are reached quickly with no waste time or motion. And it is easier to install in *smaller* spaces without sacrifice of accessibility or convenience. There's a lot of performance packed into the small and compact enclosure — 6-3/16" x 6-11/16" x 3-5/8". Because of its space-saving features, it outdistances conventional starters in design and performance.

Put these features together and you have the new Arrow-Hart "RA" 1 Magnetic Starter. You get quick, easy hook-ups, long unit life and low maintenance cost. You get a starter that's compact, sturdy and dependable mechanically and electrically — one you can rely on for outstanding performance.

NEW TYPE "RA" AVAILABLE IN SIZES 0, 1, 2 AND 3

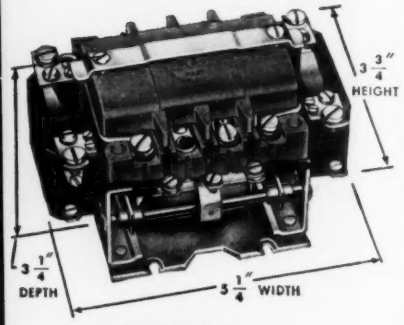
CONTROLS and APPARATUS FOR *Outstanding* PERFORMANCE

ARROW AH HART

ARROW-HART

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN ST., HARTFORD 6, CONN., U. S. A.

ARROW-HART NEW "RA" MAGNETIC STARTERS ARE EASY TO WIRE - - EASY TO SERVICE



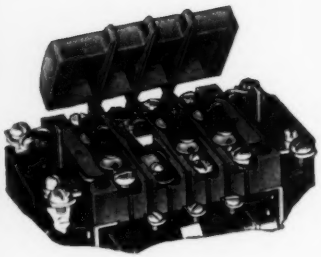
Here's Why

Simplicity of design speeds up installation and maintenance time; saves you money by shortening shutdowns. Be convinced. Loosen one screw — the enclosure cover lifts off and is free of dangling wires. Terminals are all top exposed for direct wiring. Contact inspection or replacement is made readily by loosening two hood retaining screws. Switch can be quickly removed from enclosure by loosening three mounting screws.

BIG, TOUGH CONTACTS

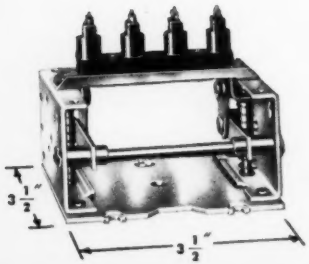
Here are rugged, heavy duty, copper contacts with special silver alloy tips that will take plenty of punishment. Special hidden spring-loaded keys provide speedy and easy change of contacts. Simply lift contact to clear guide post — permitting 90 turn of key to free contact. Replace contact and spin key into locking slot. No loose parts.

Contact surfaces after several hundred thousand cycles at 50 Ampere, 440 Volt, 50% power factor on motor load.



PLASKON ALKYD PROTECTION

New thermosetting molding compound used in A-H base and hood features phenomenally high resistance to tracking. ASTM standard test procedure proves that Plaskon Alkyd exceeds the arc resistance of the next best material by 50% to 65%. Does not support combustion. Provides hard and durable surface and superior dimensional stability. The introduction of Plaskon Alkyd is another step to insure maximum performance and long life in Arrow-Hart "RA" Magnetic Starters.



HERE'S BALANCED MECHANISM

Right angle balanced mechanism multiplies the leverage and transfers it from a vertical to a horizontal plane. Correct contact pressure is assured at all times with reduced wattage consumption of the magnet coil.

Arrow-Hart Magnetic Starters are available in sizes 0, 1, 2 and 3, to handle motors up to 50 H. P. at 440 and 550 Volt. Write for folder giving wiring diagrams, catalog data and other information.

Buy with Confidence
Profit by Performance

ARROW AH HART

THE ARROW-HART & HEGEMAN ELECTRIC CO.
103 HAWTHORN ST.
HARTFORD 6, CONN.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Here's how Life-Line motors can save you half the upkeep cost, and more.

A recent survey of 114 large motor users—operating 131,626 a-c motors of 1 to 50 hp—shows how much motors *really* cost when you figure actual "Life Cost".

The survey shows that the yearly average cost of periodically lubricated motors was $270 for every hundred motors installed.

On lubrication cost alone, Life-Line motors saved this $270. That's because Life-Line requires no periodic lubrication—no added lubrication of any kind.

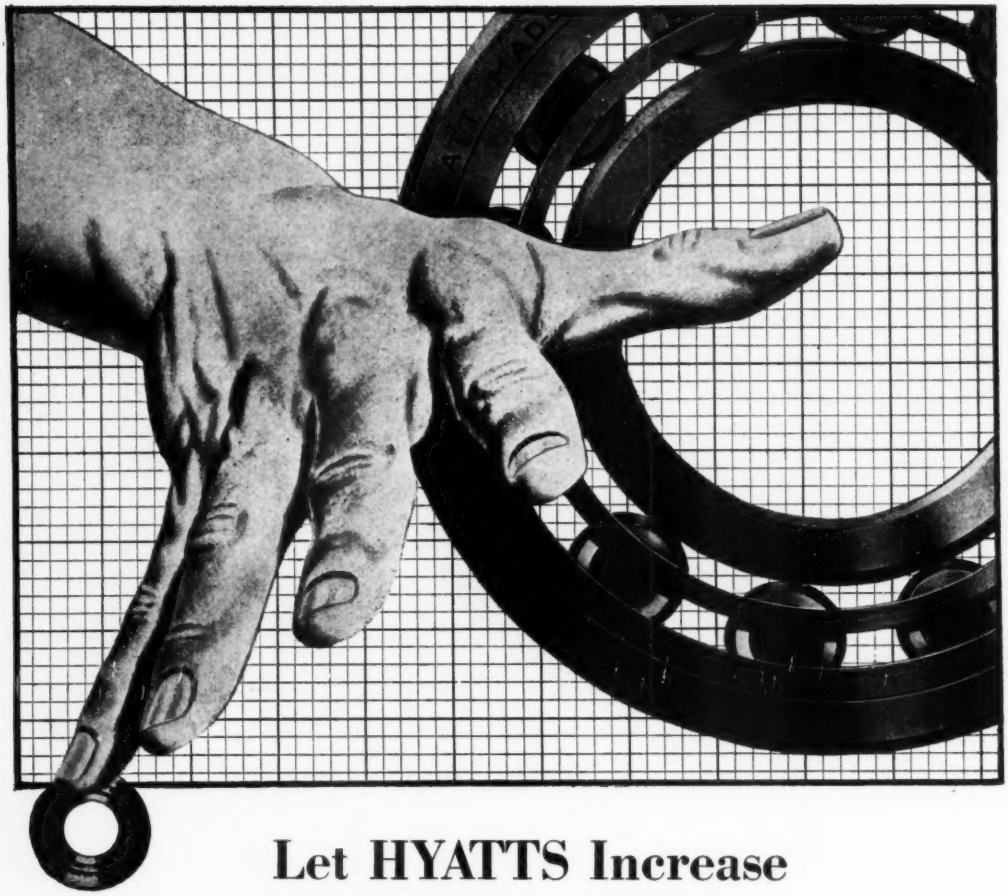
The survey also indicates that the yearly outage cost per hundred motors, for repairs and lost machine and man-hours, was $960.

The record of 500,000 Life-Line motors in service, to date, indicates a failure rate averaging less than half that of conventional motors covered by this survey. This means over 50% indicated reduction in motor outage costs—in short, a possible saving of $480 per year with Life-Line.

Add these savings—$270 for lubrication plus $480 for outages—and the result is $750 per hundred motors per year.

Can you afford to pass up savings like these? Get the facts on the savings possible in your plant. Ask your nearby Westinghouse representative for a copy of B-4321 "How to Cut Motor Costs $750". Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-21514

Westinghouse *Life-Line* Motors



Let HYATTS Increase the Life Span of Your Machinery and Equipment

If you build, sell or buy machinery or mechanical equipment, you know that wheels, gears and shafts must operate smoothly, accurately, quietly to be efficient.

Load capacity—speed—size—space are reckoned with by experienced engineers in every field who for more than fifty years have applied Hyatt Roller Bearings to machinery and equipment of every description.

With Hyatts applied in the vital positions, longer life is built in—non-stop production is assured—power costs are cut and everyone—builder, seller and buyer—is satisfied with their bearing equipment.

Perhaps we can help you. Just write to Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

NEW! — Whitney Type A Flexible Coupling now features plastic covers for reduced weight and efficient high speed operation.

WHITNEY ROLLER CHAIN
Flexible Couplings

For
Positive, Yet Flexible
Direct Drives

Here's a Flexible Coupling that supplies the equipment manufacturer and machine user with a *practical* and efficient unit for connecting power equipment to direct drives. Note the simple, all-steel construction . . . no short-lived materials to wear out or replace! Precision Roller Chain, assembled around accurately cut, hardened steel sprockets provide positive operation with inherent flexibility . . . assures long life. Additional Whitney features include: ease of installation, compactness, allows for motor end play, disconnects without removing shafts and bearings, allows for slight shaft misalignment. These are good reasons why you should specify and use Whitney Flexible Couplings for lasting, all-round performance and machine protection.

Whitney Roller Chain Flexible Couplings are adaptable to a wide range of transmission service, covering light, medium or heavy loads. You can use them to connect electric motors, gasoline engines, diesel engines, steam engines, etc., to any direct drive units, such as pumpers, compressors, blowers, beaters, speed reducers, —in short, to any of your production machinery where a positive but flexible direct drive is required.

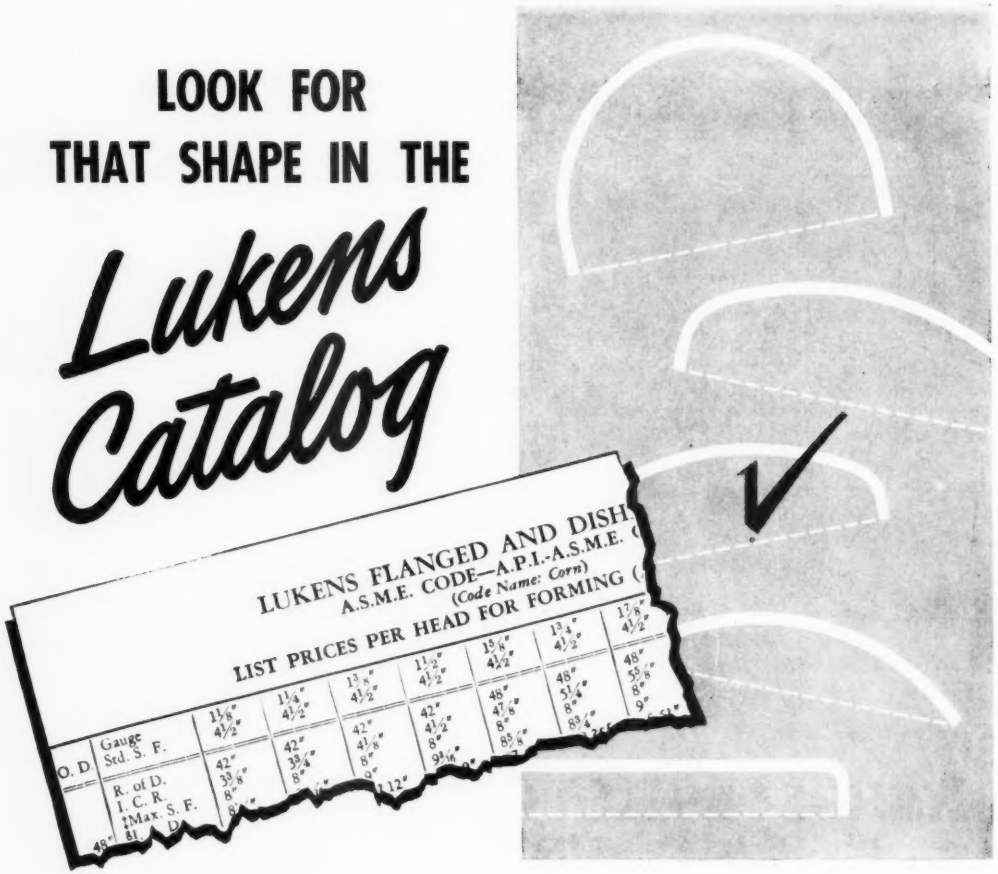
Available from factory or distributor stock in popular sizes covering a wide range of application — from fractional to hundreds of horsepower. For complete information and engineering bulletin, write us today.

OTHER WHITNEY CHAIN PRODUCTS

- Roller Chain—single and multiple widths
- Silent Chain
- Conveyor Chain
- Cut Tooth Sprockets

Whitney Chain & Mfg. Co.
Division of Whitney-Hanson Industries, Inc.
204 HAMILTON STREET, HARTFORD 2, CONN.

LOOK FOR THAT SHAPE IN THE *Lukens Catalog*



No need to design a special shape when a Lukens Head-Shape will fill the bill. You get into production faster because dies are already available for forming it. You avoid expensive die charges and, in many cases, save on machining time.

Detail dimensions on 3,989 standard head-shapes are given in Lukens Catalog No. 1, "Flanging and Pressing". You have only to transfer them to the drawing of the tank, pressure vessel, machine or other product you are planning. Hundreds of manufacturers of all kinds of equipment have found Lukens Head-Shapes a short cut to speedier production and lower costs.

Lukens produces head-shapes from four inches to over twenty feet in diameter. Thicknesses range from $\frac{3}{16}$" to 6½ inches. Lukens makes head-shapes of carbon and alloy steels, including stainless; nonferrous metals such as nickel, Monel and Inconel, aluminum and silicon bronze; and the widest range of clad steels available anywhere.

May we quote on your head-shape requirements? Bulletin 433 shows the sizes and gages of carbon steel heads regularly stocked and ready for immediate shipment. Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

LUKENS HEADS

Be sure to see us at Booth Nos. 558-563 at the Chemical Show, New York City, November 28-December 3.

FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

COST-CUTTERS
"made-to-order" for you!

FULTON SYLPHON
STAINLESS STEEL
BELLOWS ASSEMBLIES

If your products require stainless steel bellows assemblies, it will pay you to find out how Fulton Sylphon can help you make important savings.

For example, designing and producing these intricate assemblies is a Fulton Sylphon specialty—backed by nearly half-a-century of successful experience in this field.

Our skilled craftsmen know how to produce simple or complex stainless steel bellows assemblies exactly to your specifications. What's more, we'll help you in the design and development of any new type of assembly . . . confidentially, if you wish.

These abilities, plus complete production facilities, can save you time and worries. They help cut your production costs—insure your getting assemblies that help your products perform at their best.

Whatever you need bellows assemblies for . . . thermostatic devices, pressure controls, hydraulic mechanisms, valves, shaft seals, expansion chambers, recording instruments, or other applications . . . find out how Fulton Sylphon can help you save money and improve your products' performance.

Write today—ask for free Bulletin TP-1200 that gives you further information.

FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

ROBERTSHAW-FULTON CONTROLS CO. KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

WHEN TO USE FEDERAL SINGLE ROW RADIAL FELT SEAL BALL BEARINGS

Where dirt, dust or other foreign matter is a problem—with combined radial and thrust loads in any direction—the design and operating features of Federal Single Row Radial Felt Seal Ball Bearings hold the answer.

These bearings provide effective protection of the vital bearing parts. The felt is held securely between two plates fitted into a groove in the outer ring. The seal rides on a frictionless surface on the shouldered inner ring. Either single or double seals can be provided for any size, in standard or wide outer ring types.

Federal Felt Seal Ball Bearings incorporate all the load-carrying advantages of Federal Conrad Type Bearings. In load combinations, thrust loads up to 50% of the radial rating can be applied. For pure thrust the rating is 100% of the rated radial load.

In our catalog "K" you'll find detailed descriptions of these and all bearings in the Federal line—every type and size, shielded and sealed—for every anti-friction need. Its 260 pages contain ball bearing selection charts to help you compute bearing loads, determine capacities at every speed, and select the type and size bearing best suited to your individual application. Write for your copy today.

THE FEDERAL BEARINGS CO., INC. · POUGHKEEPSIE, N. Y.

Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT
2640 Book Tower, Detroit 26, Michigan • 8 South Michigan Ave., Chicago 3, Illinois
Chester-Twelfth Building, Cleveland 14, Ohio

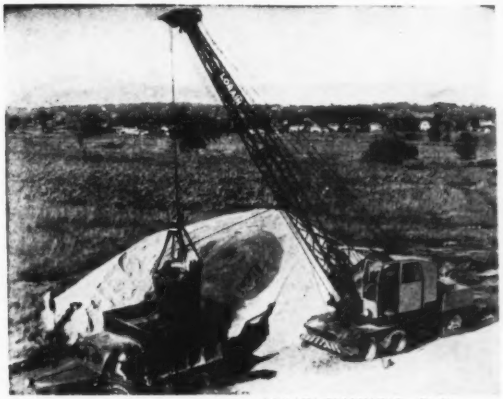
Quality since 1908

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

TAGLINES OR DIPPER-TRIPS--

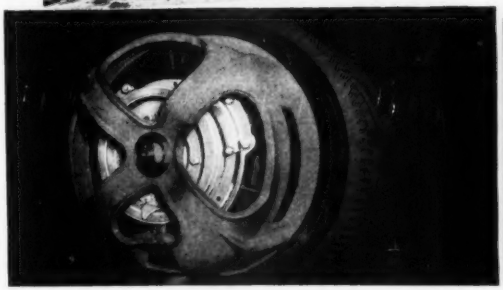
WARNER ICB UNITS* GIVE YOU FASTER, MORE ACCURATE CONTROL



LORAIN CLAMSHELL Tagline Controlled by Warner ICB Unit.

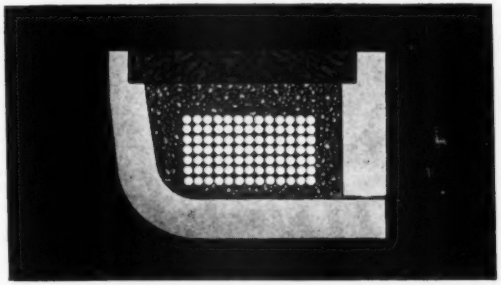
LORAIN SHOVEL — Warner ICB Unit equipped

THEW-LORAIN SHOVELS AND CRANES USE a Warner Electric Industrial ICB Unit* on the tagline and dipper-trip reel. It continuously maintains exact tension to precisely position a clamshell or magnet and keep them steady without twisting. Flexibility of control permits a larger working area without repositioning machine or boom. When used with a shovel — it keeps dipper-trip line constantly taut and trips dipper at finger touch.



WARNER ICB UNIT* AS INSTALLED on Thew Shovel. Note simple compactness, easy accessibility. ICB Units are self-adjusting for life. Push-button and rheostat give instant finger-tip control. There's a complete range of sizes to meet various requirements for positive acting, sensitive controlled clutches or brakes for industrial use.

ARMATURE SECTION: One of only two parts for either Clutch or Brake actuating units. Consists of magnetic segments welded to steel back-plate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . thus keeping full magnet contact at all times.



MAGNET SECTION: The other of the two parts for either Clutch or Brake actuating units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut) uses both friction plus magnetic attraction for lightning fast, super-powerful clutch or brake action.

● Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write:
Industrial Division, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

WARNER
ICB UNIT*

*ICB Unit — The trade designation for The Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

6 OPERATIONS ELIMINATED

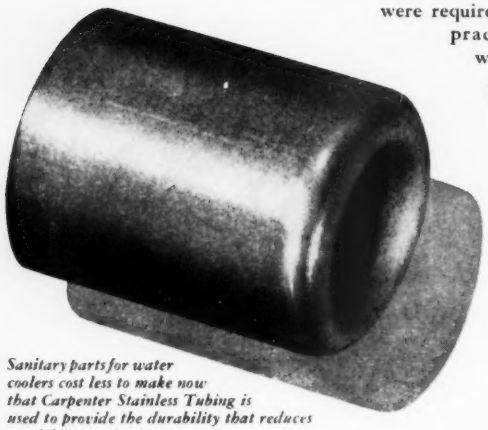
when they changed to Carpenter Stainless Tubing...

This job is exceptional, but it shows what *can* happen to unit costs when you make use of Carpenter's experience with Stainless Tubing.

Unit costs were way out of line and rejects were piling up on the floor when this water cooler part was made from sheet. Seven operations were required on each part. Silver soldering of finished units was practically impossible because the fabricated material would not satisfactorily withstand high temperatures.

Now, water cooler parts are fabricated in one reverse bending operation from Type 304 Carpenter Stainless Tubing. Six operations, ranging from the slitting of sheet to the annealing of fabricated parts, have been eliminated and the soldering of assemblies is a snap.

To find ways to save time and reduce unit costs on your own jobs, put our Stainless Tubing experience to work. It will cost you nothing and may save you plenty.



Sanitary parts for water coolers cost less to make now that Carpenter Stainless Tubing is used to provide the durability that reduces servicing costs.

THE CARPENTER STEEL CO.
Alloy Tube Division • 121 Springfield Road • Union, N. J.

NEW FILE FOLDER OF DATA ABOUT STAINLESS TUBING

For useful information about physical properties, heat resistance characteristics, standard sizes, etc., write on your company letterhead and ask for the 12-page Carpenter Stainless Tubing Data File Folder.

24-Hour Service On Your Orders...
You get definite delivery information within 24 hours when you call your Carpenter Stainless Tubing Distributor.

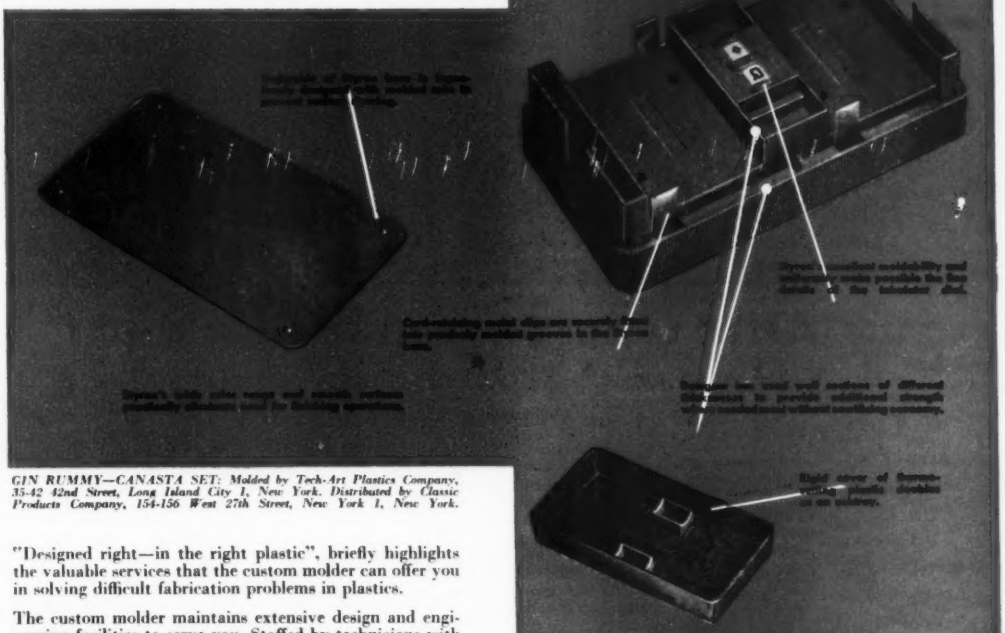
Carpenter
STAINLESS TUBING
"MORE THAN CORROSION RESISTANCE"

THE CUSTOM MOLDERS' DESIGNING KNOW-HOW PLUS

STYRON

solves another production problem!

ANOTHER CUSTOM MOLDING CASE HISTORY



GIN RUMMY—CANASTA SET: Molded by Tech-Art Plastics Company, 35-42 42nd Street, Long Island City 1, New York. Distributed by Classic Products Company, 154-156 West 27th Street, New York 1, New York.

"Designed right—in the right plastic", briefly highlights the valuable services that the custom molder can offer you in solving difficult fabrication problems in plastics.

The custom molder maintains extensive design and engineering facilities to serve you. Staffed by technicians with long experience in engineering the correct plastic into finished products, these facilities furnish you with first-hand information on the properties and performance of various plastic materials.

The Dow Chemical Company works with Custom Molders to help them utilize Dow Plastics to the best advantage in your products. Write Dow today and let us put you in touch with qualified Custom Molders, who can solve your problem.

Plastics Division, Dept. T-57

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

DOW plastics

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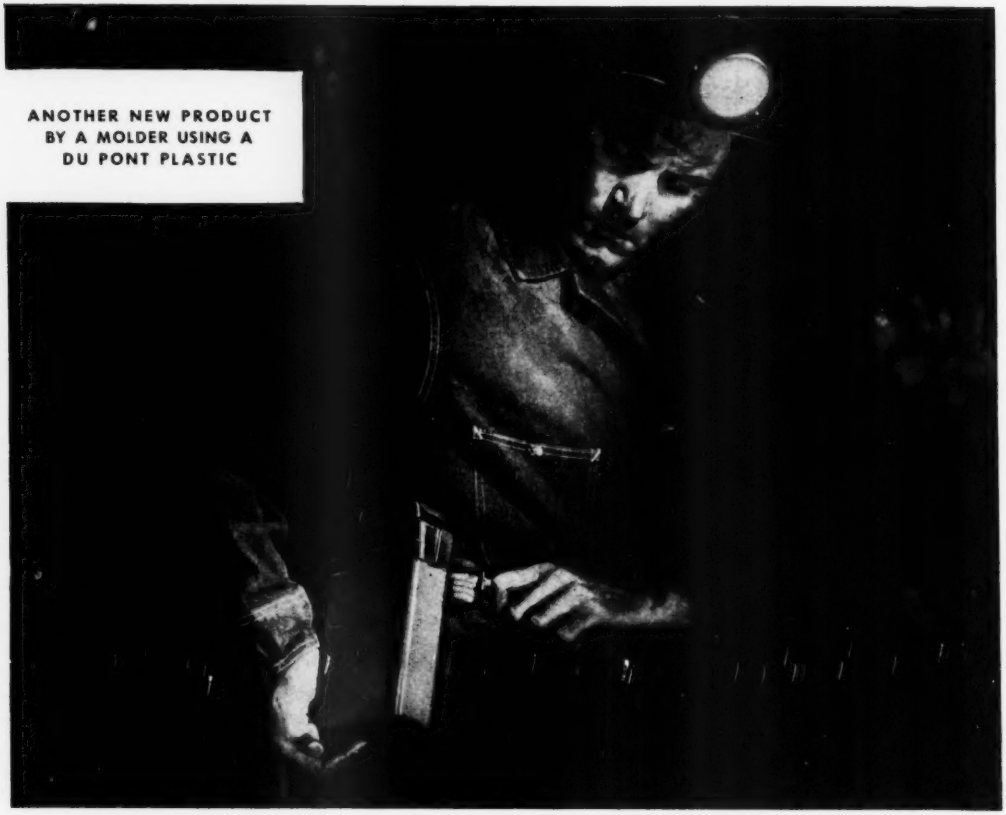
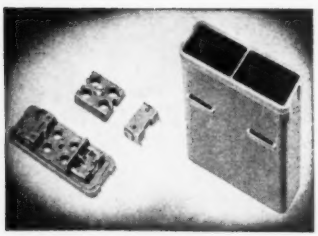


NYLON PLASTIC CARRIES 25% MORE LIGHT FOR MINERS

New battery case of molded Du Pont nylon contributes to better vision, greater efficiency and safety



THE INTRICATE DESIGN and precision molding can readily be seen in these nylon parts of the battery case. One of nylon plastic's most practical features is its ability to be molded in various sizes, shapes or thicknesses, retaining high strength and impact resistance. In the assembly, four leak-proof valves for the cells are mounted in a single nylon plastic block. Parts fall in place with hair-line accuracy. Then the case is sealed by the magnetically locked cover.

This battery case for the new EDISON miners' cap lamp contains four cells instead of the conventional three. Yet there's no appreciable increase in size or weight in the battery case over the former 3-cell models. The increased voltage and wattage of the battery permits the use of a bulb that lasts longer and throws off a stronger beam of light.

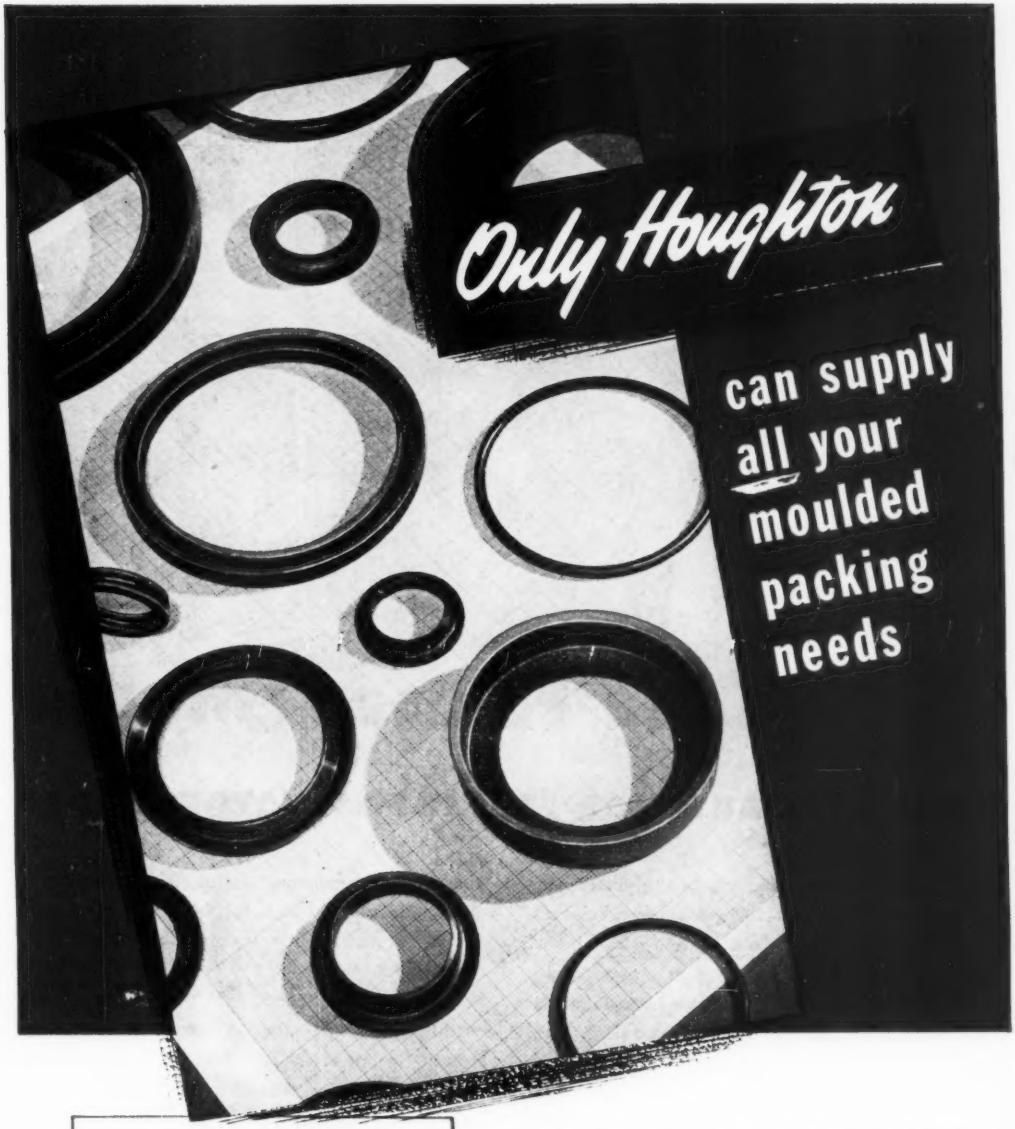
Nylon was the choice of Thomas A. Edison, Incorporated, the designers, because it serves both as insulation between the steel cells of the battery and as an outer case which combines light weight and compactness with resistance to abrasion, impact and corrosive mine waters.

Maybe there's a spot on your production line for nylon's outstanding properties. It's easy to get the facts on nylon and all other Du Pont plastics. Write our most convenient office for literature.

E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Main Sales Offices: 350 Fifth Ave., New York 1, N. Y.; 7 S. Dearborn St., Chicago 3, Ill.; 845 E. 60th St., Los Angeles 1, Calif.

Nylon parts molded by Vulcanized Rubber and Plastics Co., Morrisville, Pa., for Thomas A. Edison, Incorporated, West Orange, N. J.

DU PONT
REG. U.S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY



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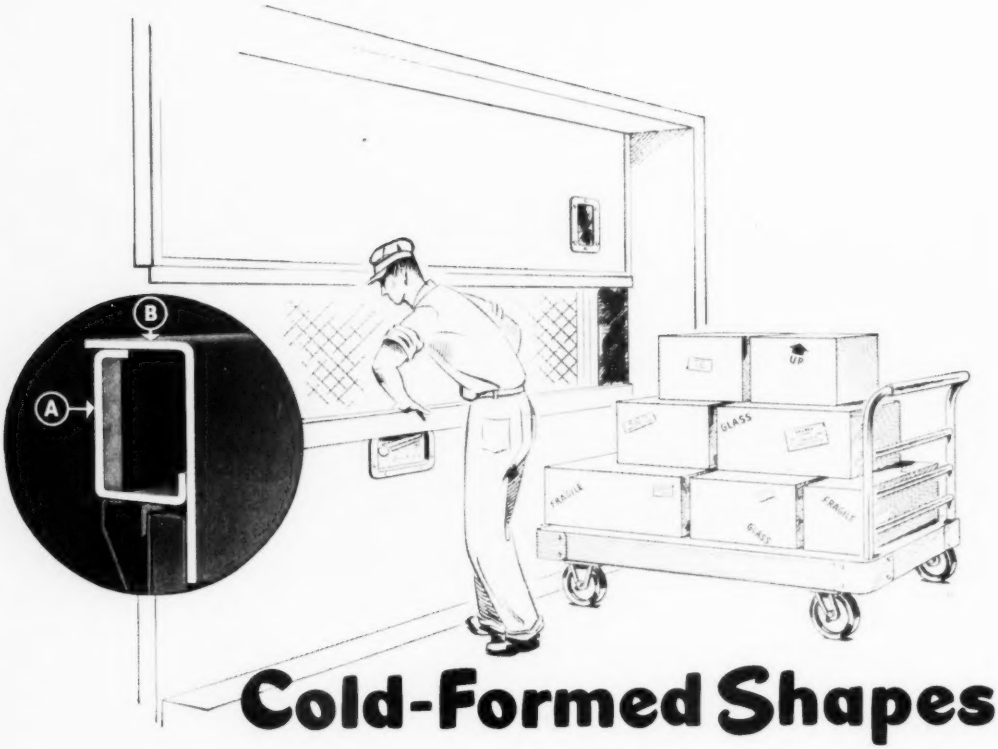
and
VIX-SYN RUBBER
Engineered
PACKINGS

No one type of packing will fill all needs. That's why we supply all kinds: VIM Leathers of many shapes and consistencies, Vix-Syn fabricated and homogeneous synthetic rubber, and "O" rings. This complete line enables Houghton to make unbiased recommendations based on service conditions. We invite inquiries for both packings and engineering advice. Write—

E. F. HOUGHTON & CO.
303 W. Lehigh Ave., Phila. 33, Pa.



Cold-Formed Shapes

USED BY MAKER OF FREIGHT-ELEVATOR DOORS

When welded together as shown, these two Bethlehem Cold-Formed Shapes provide a reinforced tubular sill for freight-elevator doors—a sill so sturdy that it can stand plenty of hard usage from trucks during loading and unloading operations. We make the shapes on brakes from (A) 11-gauge, and (B) 7-gauge sheet steel, and furnish them to the customer in various lengths.

Sills for freight-elevator doors . . . frames for house trailers . . . parts for ornamental railings . . . reinforcing for kitchen equipment . . . these are but a few of hundreds of widely-varied uses for Bethlehem Cold-Formed Shapes. And hardly a day passes but some alert manufacturer thinks up a new use for these versatile shapes.

Bethlehem Cold-Formed Shapes are made either from strip, sheet or plate steel. They are uniform in thickness, have an excellent strength-weight ratio, and relatively scale-free surface. We make them in all gauges from 7 to 24, inclusive, and because of our special shop facilities we can meet virtually every requirement.

If you consider there might be a place in your manufacturing operations where Bethlehem Cold-Formed Shapes could be used to advantage, let us discuss possibilities with you. Your query to our nearest sales office will receive prompt attention.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

YOU CAN BE SURE.. IF IT'S
Westinghouse

... rolls more tons in steel mills, for example

Bearings used in steel mills must be tough . . . to withstand pressures as high as 8,000 lbs. per square inch, or shaft speeds that exceed 1,800 rpm.

That's why steel men use Micarta. It outwears other types of bearings many times . . . lasts up to 70 times longer than metals. It's typical of the way Micarta serves industry, and may suggest ways Micarta can improve your product or your production.

In many cases, Micarta bearings operate in water, and water is its best lubricant. Whether lubricated with water, oil or grease, it has a low coefficient of friction, affording power savings as high as 25%. Its smooth, self-polishing surface prevents scoring of shafts.

Micarta is ideal for many other tough jobs in industry . . . jobs that call for strength with light weight; resistance to moisture and corrosion; high dielectric strength; resistance to heat and cold.

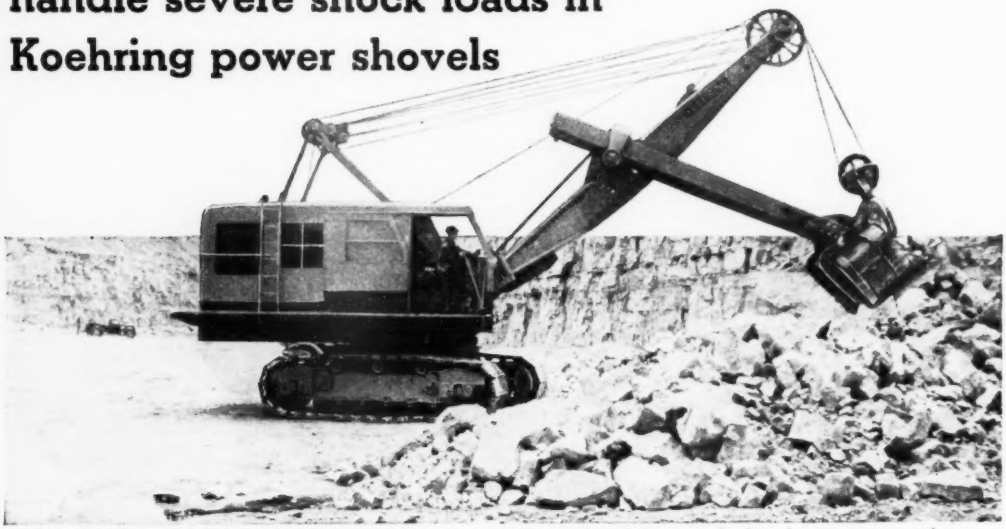
Ask your nearby Westinghouse office for Micarta Data Book B-3184-C, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

J-06420

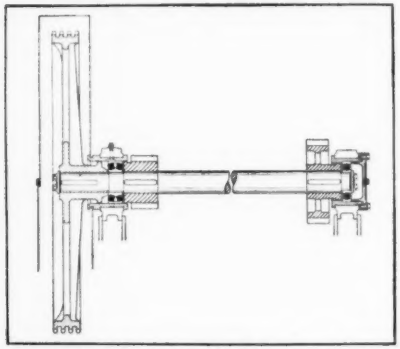
Micarta

WESTINGHOUSE

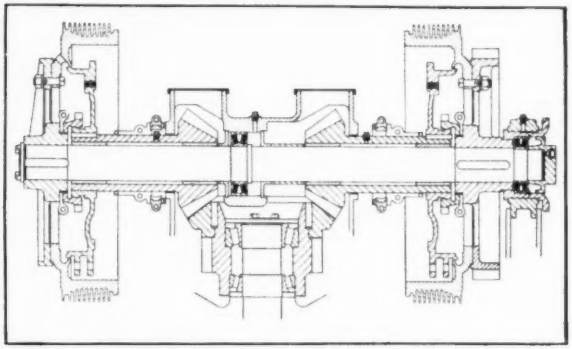
Torrington Spherical Roller Bearings handle severe shock loads in Koehring power shovels



Power Shovels made by Koehring Company, Milwaukee, are built to withstand the severe shocks and strains encountered in this rugged service. Among many advanced engineering features is the use of Torrington Spherical Roller Bearings on the swing and traction shaft and the countershaft. They compensate for deflection and prevent binding under shock loads.



Cross-Section of the countershaft shows how a Spherical Roller Bearing is used to maintain free-rolling alignment despite the overhung sheave and sudden stresses of operation. These heavy-duty bearings carry high loads with an ample margin of safety.



Two Spherical Roller Bearings are used on the horizontal swing and traction shaft. Here, too, the self-aligning feature is important, insuring accurate alignment of bearings spaced some distance apart. Because they carry thrust loads in either direction, these bearings also locate the shaft axially, preventing play and helping to minimize wear on bevel gears.

Heavy-duty equipment, subject to severe strain and shock loads in operation, operates freely and reliably on self-aligning Spherical Roller Bearings. Our engineers will be glad to be of assistance to you in the design and application of Spherical Roller Bearings to your equipment. Write us today. THE TORRINGTON COMPANY, South Bend 21, Ind., or Torrington, Conn. District offices and distributors in principal cities of United States and Canada.

TORRINGTON SPHERICAL ROLLER **BEARINGS**

Spherical Roller • Tapered Roller • Straight Roller

Needle • Ball • Needle Rollers

"Just when I was trying to make an impression!"

PERHAPS the spring failure in this young man's lighter is of little consequence. But if the manufacturer of that lighter has placed poor quality springs in many other lighters, he's headed for trouble . . . and very likely for the loss of some business.

We'll admit that most precision-made springs seldom fail. But it's sound business sense to get that extra "performance insurance" by using the *best* spring wire.

We believe that the best spring wire available is U·S·S Amerspring Music Wire. Here's why . . .

Amerspring combines high tensile strength with unusual toughness. It has outstanding resistance to fatigue. And it has the stamina, resiliency, uniformity and freedom from defects that are imperative for top performance of small, precision springs.

For many years we have supplied this high quality Music Wire to manufacturers of calculating machines, cash registers, typewriters, and other makers of equipment who use precision springs. We believe that the performance of the springs in those products . . . and the year-in-year-out repeat orders we have had from these customers . . . are ample proof that U·S·S AMERSPRING IS THE LEAST EXPENSIVE WAY TO SUPERIOR PERFORMANCE.

We'd like to discuss the use of U·S·S Amerspring Music Wire for your springs. And once again we can report—AVAILABLE NOW—IN THE MILL QUANTITIES YOU NEED.

If you use Music Steel Spring Wire . . . use Amerspring

USS

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

ALUMINUM TAKES THE BITE OUT OF *Jack Frost*

"Frostguard" by Evans Products Co.

BATTLING Jack Frost with infra-red rays is an idea developed by a pioneering group of agricultural engineers. The principle is to balance heat loss from plants and the ground during frost conditions, by application of heat rays.

The "Frostguard", pictured above, consists of an oil-fired heat chamber and umbrella-like canopy. Reynolds *Lifetime* Aluminum sheet was specified for the canopy because of its efficient reflectivity, freedom from red-rust and light weight. Infra-red rays are generated in the stainless steel chamber. Gases pass up and out a flue, but warming rays are reflected downward by the aluminum canopy.

Average coverage for a "Frostguard" is ½ to 1 acre, and it has successfully combated cold as low as 20° Fahrenheit. Nor has its usefulness been confined to crop protection. "Frostguard" has extended truck-farm growing seasons by four to eight weeks; protects outdoor workers during inclement weather.

Where can Reynolds *Lifetime* Aluminum improve your product, lower costs and increase sales? This strong, lightweight metal handles faster on the production line—costs less to ship as complete assemblies. Freedom from rust makes for longer life, frequently eliminates one or more finishing operations. And whether the need is for pig, ingot, sheet, plate, wire, rod, bar, screw machine stock, pipe, tubing, structurals or extrusions, Reynolds has it in an alloy and size to fit your specifications.

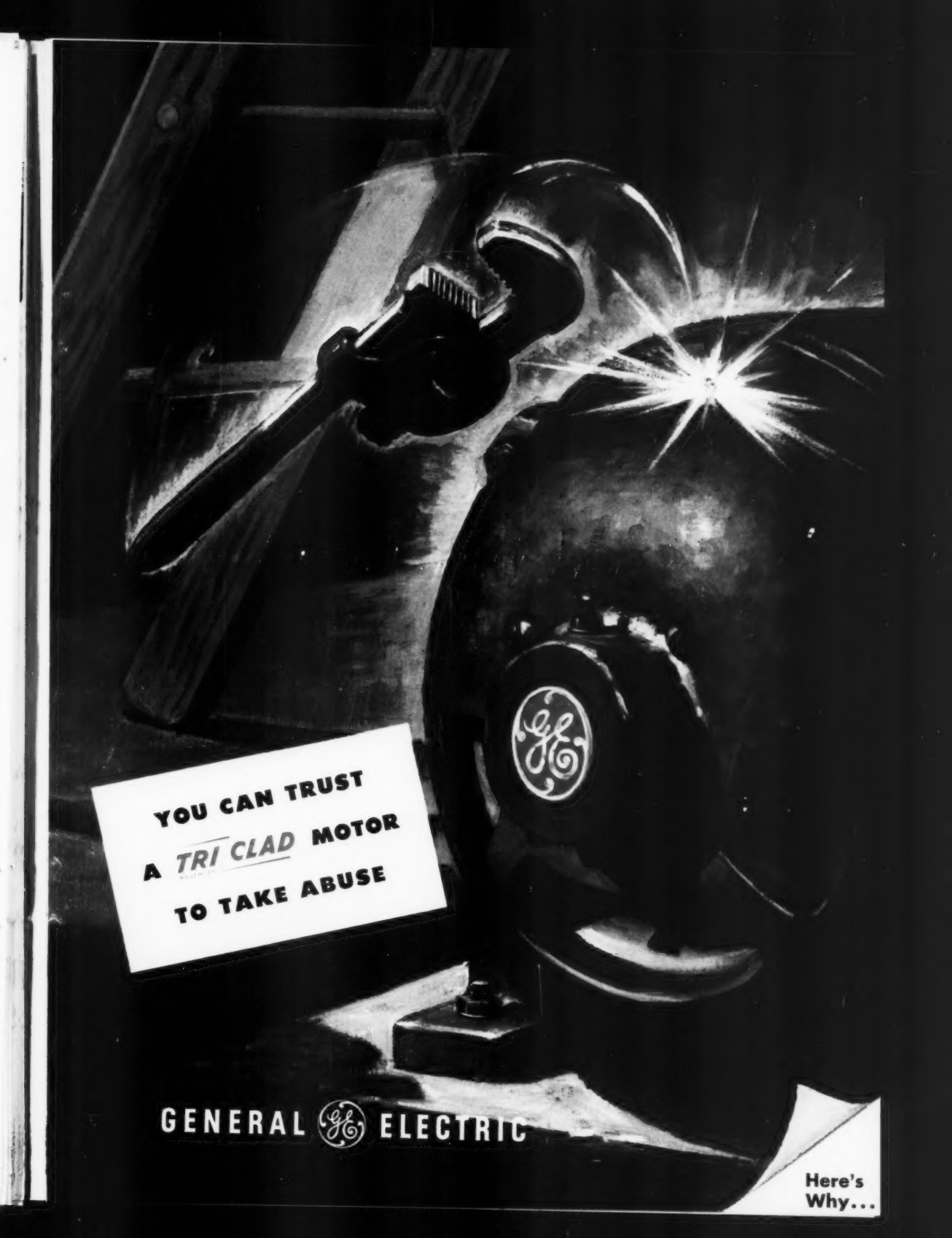
For complete information, call the Reynolds Distributor in your area—the nearest Reynolds Sales Office—or write direct to Reynolds Metals Company, Aluminum Division, 2524 South Third Street, Louisville 1, Kentucky.

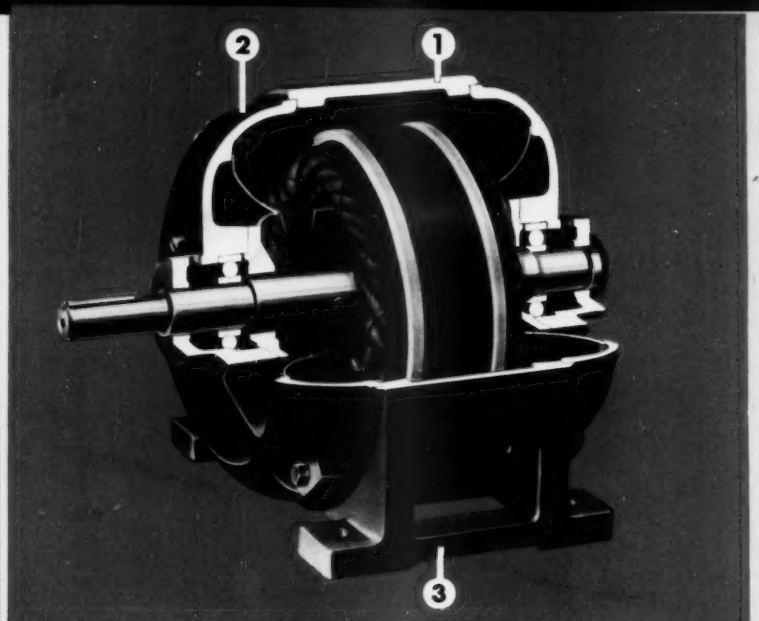
ALUMINUM SHEET AND PLATE

Request this informative book on your company letterhead and receive a copy without charge.

REYNOLDS *Lifetime* ALUMINUM

CONSIDER ALUMINUM...CONSULT REYNOLDS...THE COMPLETE ALUMINUM SERVICE


YOU CAN TRUST
A TRI CLAD MOTOR
TO TAKE ABUSE
GENERAL ELECTRIC
Here's
Why...



Notice the thick cross sections of a Tri-Clad's husky cast-iron stator frame (1) and end shields (2) . . . the integrally cast feet (3). Here you have a *rigid structural unity* that no other general purpose motor we've seen can match. Distortion of bearing alignment is well nigh impossible, even by severe blows, careless installation, or the heavy continuous radial loads some industrial drives impose. Notice, too, how Tri-Clad double-end ventilation provides *uniform* "air conditioning" throughout the motor.

You can trust a *TRI CLAD* motor to take abuse

Teeth-rattling blows – accidental jarring – dripping liquids – they're all in a day's work for a Tri-Clad motor – the toughest general-purpose motor that hard-headed plant management can buy.

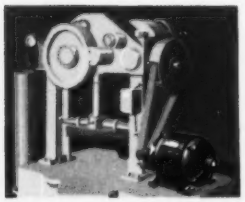
The cast iron structure which today protects more than a million and a half Tri-Clad motors, is one big reason for its stamina. It absorbs the shock of accidental blows and falling objects encountered in rigorous industrial service. It provides vastly superior resistance to rust and corrosion. Moreover, cast iron won't take on an injurious permanent "set"; thus it assures accurate shaft alignment and a permanent air-gap for the life of the motor. Thick-ribbed cast-iron end shields, too, take more than their share of punishment.

Want to standardize on a line of motors that can really **TAKE ABUSE?** Local stocks of Tri-Clad motors in your area mean **QUICK DELIVERY.** *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

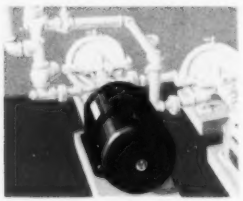
GENERAL ELECTRIC

760-11

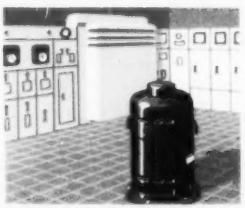
YOU CAN'T BEAT TRI CLAD EXTRA PROTECTION



G-E open (drippproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.

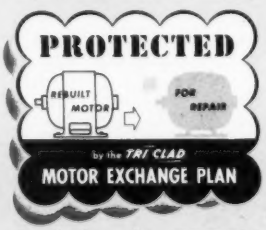


G-E totally enclosed motors for outdoor operation, in abrasive dusts, or corrosive fumes. From 1 to 1000 hp.



G-E vertical induction motors for pump drive, in streamline design. From 1 to 500 hp.

G-E capacitor motors for use on fans, blowers, pumps and compressors, with single-phase power. From ¾ to 5 hp.



Look for this **EXTRA** on the motor you buy!

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Bead chain has many applications—Courtesy Bead Chain Co., Bridgeport, Conn.

Bead Chain Finds Wider Uses

Everyone is familiar with Bead chain so popular for electric light pull sockets and key chains, but few realize how clever it is in construction.

Bead chain is made automatically. Two coils of narrow strip metal are fed into an ingenious machine and endless chain made of hollow balls joined by a hollow bar (dumbbell construction) comes out from the opposite end.

Metal workers recognize the genius behind the construction of this type of automatic equipment. They know the importance of close precision which enters into the machine construction, the tools and the metal used for making this type of chain. The hollow balls range from 3/32" to 1/2" O.D.

In recent years Bead Chain Company has been finding new applications:

Shower curtain hooks for Bridgeport Traxrod ride on Bead chain hollow balls.

fishing leaders; and costume jewelry—bracelets, chokers, necklaces; bathroom accessories such as Traxrod shower curtain rods, curtain tie backs, rubber stopper chains. Other applications include pulls on venetian blinds, attachments for container caps, nuts for split bolt connectors, keys to miniature flashlights, pencils and pens to pads, loops for hanging heavy coats, telephone books, brooms, brushes, mops, whistles, etc.

High Strength Alloys Increase Industrial Possibilities

Yellow brass is most commonly used for most varieties of Bead chain because of its easy workability and low tool wear. For key chains, much of it is simply bright dipped and lacquered. For plumbing, it is generally nickel and chromium plated. For costume jewelry, red brass and copper are used because the natural, rich warm gold colors are very attractive.

The manufacture of Bead chain is not strictly confined to brass. Alloys such as phosphor bronze, silicon bronze, nickel silver, aluminum bronze and cupro nickel impart much higher strength, and greater resistance to corrosion and wear. This widens its possibilities for industrial applications and offers a challenge to design engineers.

Silicon Bronze Improves Faucet Screws

Most of us have repaired leaky faucets by replacing worn-out rubber or composition washers; and, while taking out the holding screw, had the screw crumble or break off. Then the long, ticklish job of removing the broken stem begins.

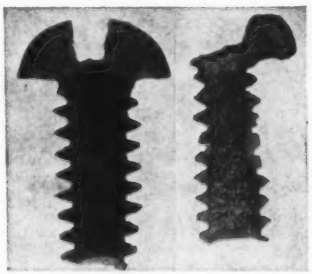
Isn't it true that many an excellent product is often condemned through the failure of one small part?

Why did the screw crumble? Microscopic examination revealed dezincification; caused by the carbonic acid, salts, gases and other impurities in the water. Higher temperatures in the hot water line accelerates corrosion, speeding dezincification. Analysis showed it contained 62% copper and 38% zinc.

Product Analysis Desirable

If the designer had called for a silicon bronze screw, instead of yellow brass, this type of failure would not have occurred. Bridgeport's 609 Silicon Bronze, which contains about 98% copper and 2% silicon, is easily cold headed and roll threaded.

Many manufacturers are utilizing the newer copper-base alloys with the idea of removing from their products the "weakest link" which may involve corrosion, wear or fatigue. In the choice of alloys, Bridgeport's Laboratory is prepared to serve customers.

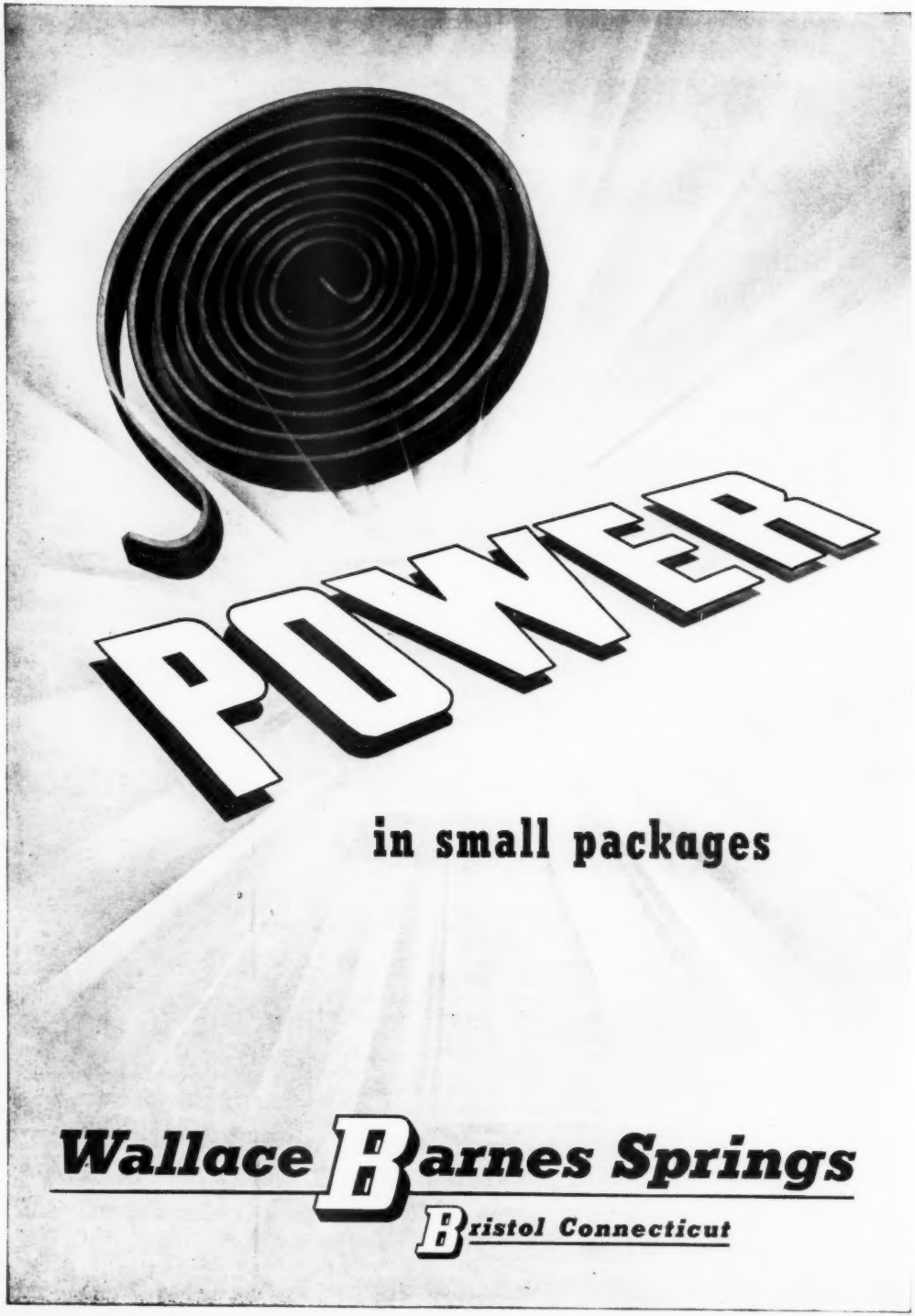


Left—Silicon Bronze screw in service for same period under similar conditions.*
Right—Yellow brass faucet screw dezincified and crumbled after one year in contact with well water.
Mag 5X Etch $NH_4OH + H_2O_2$

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
In Canada:
Noranda Copper and Brass Limited, Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*


POWER
in small packages
Wallace Barnes Springs
Bristol Connecticut

150S

WORLD'S MOST VERSATILE ALUMINUM ALLOY

NOW HERE TO CUT COSTS—YET IMPROVE PRODUCTS

Here are important facts about a remarkable new Kaiser Aluminum Alloy:

Unusually versatile—a cold rolled alloy that's stronger than 3S, more workable than 52S.

First alloy ever developed specifically to meet problems of fabricators and engineers.

Thoroughly proved in two years of research, testing and practical production experience.

Exclusive Permanente Metals' development.

If you are now using 3S or 52S, you may be able to cut material costs and give your product better design by using Kaiser Aluminum Alloy 150S.

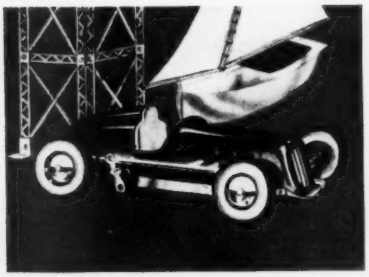
On the next page, read about the unique combination of advantages of...

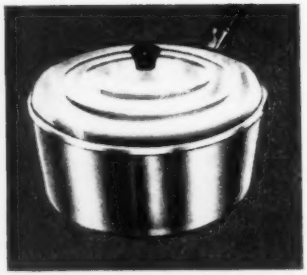
150S—Remarkable New

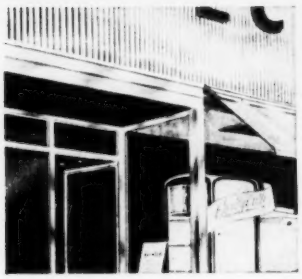
***Kaiser Aluminum* Alloy**

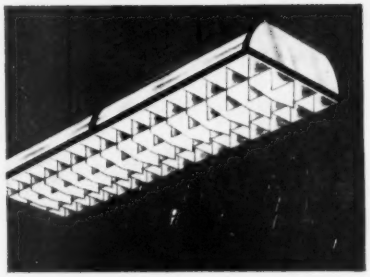
150S . . . WORLD'S MOST

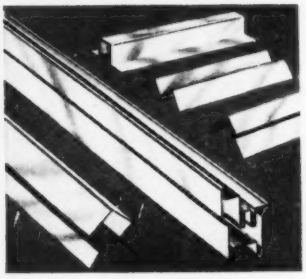
NOW HERE TO CUT COSTS—YET IMPROVE PRODUCTS











No other alloy can be fabricated in so many ways to do so many jobs—because no other alloy so effectively combines ALL *these advantages:*

GOOD PHYSICAL PROPERTIES. Yield strength and workability have been established to make it suitable for the widest variety of applications.

GOOD WORKABILITY. Most single, double and triple stage drawing can be done. With proper equipment spinning can be done satisfactorily. Beading formed by dies in a press can be handled well. Roll forming, brake forming, and lock seaming can be accomplished easily.

VERY FINE GRAIN STRUCTURE. Its chemical composition makes Kaiser Aluminum 150S inherently a fine grain alloy, uniform in all tempers.

EXCEPTIONAL FINISHING PROPERTIES. Satin anodized finishes, with a silvery white color, fine texture and consistent uniformity, can be obtained. Many finishing operations can be eliminated. And the hard surface resists scratches.

GOOD WELDING AND BRAZING PROPERTIES. Heliarc welding, spot welding and brazing can be done.

EXCELLENT CORROSION RESISTANCE. 150S has salt corrosion resistance properties comparable to 52S.

ARE YOU NOW USING 3S?

Here are definite advantages you get with 150S:

- 30 to 40 per cent greater strength in finished parts.
- Very nearly the same workability you now get with 3S.
- Harder, more scratch-resistant surface.
- Uniform, finer grain texture in all tempers.
- Fast, high lustre buffing.
- Superior etch finishes—clear, white, uniform.
- Anodized finishes superior in color to 3S.
- Up to 10 per cent less material cost where extra strength allows gauge reduction—only slightly higher cost for equal gauges.
- Corrosion resistance, welding and brazing properties equal to or better than *3S*.

ARE YOU NOW USING 52S?

These advantages will be yours with 150S:

- Superior workability.
- Decided cost advantage if you're using 52S overstrength.
- No Lueder lines or strain markings in shallow draws.
- Finishing characteristics, corrosion resistance, welding and brazing properties equal to or better than *52S*.

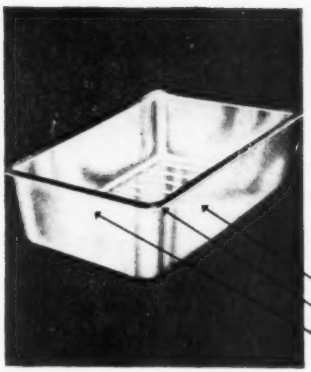
Kaiser Aluminum Alloy 150S may offer you sufficient strength at low cost to make conversion to aluminum from other materials *permanent* and *profitable*.

VERSATILE ALUMINUM ALLOY

TYPICAL TENSILE PROPERTIES OF VARIOUS 150S TEMPERS

Here are typical figures for thicknesses of about .040" to .051". Elongations are slightly lower for thinner sheet, slightly higher for thicker sheet.

Temper	Tensile strength	Yield strength	Elongation % in 2"
150S O	21,000 p.s.i.	8,500 p.s.i.	25%
150S H 22	23,500 p.s.i.	16,500 p.s.i.	13%
150S H 32	25,500 p.s.i.	21,000 p.s.i.	9%
150S H 34	28,000 p.s.i.	24,500 p.s.i.	6%
150S H 36	30,000 p.s.i.	27,000 p.s.i.	5%
150S H 38	32,000 p.s.i.	29,000 p.s.i.	5%
150S H 18	33,000 p.s.i.	31,000 p.s.i.	4%
150S H 19	37,000 p.s.i.	35,000 p.s.i.	3%



But that's not the whole story of the greater strength of 150S! Here are typical yield strengths of 150S compared with 3S:

Yield strength, p.s.i.				% increase with 150S
3S O:	7,000	150S O:	8,500	21.5%
3S H 12:	17,000	150S H 32:	21,000	23.5%

When drawn parts of the two alloys are compared, the difference in strength is even greater! Here, for example, is a comparison of drawn parts of a refrigerator crisper pan:

Test location	Yield strength, p.s.i. 3S	150S	% increase with 150S
Side	19,200	26,100	35.9%
Flange	17,700	24,500	38.4%
End	16,400	22,300	36.0%

GET THESE COMPETITIVE ADVANTAGES WITH 150S: If you are now using 3S, 52S, copper, brass, steel, or other materials, you may be able to cut manufacturing and equipment costs—and improve your product and fabrication techniques—with Kaiser Aluminum 150S! Today—call or write the nearest Permanente Products' sales office for more information on the world's most versatile aluminum alloy—150S!

See production samples of Kaiser Aluminum Alloy 150S at the *Annual National Metal Congress and Exposition—Cleveland, October 17–21.*

Permanente Metals

PRODUCER OF

Kaiser Aluminum

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:
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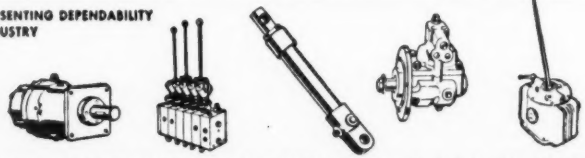
THESE FAMOUS EMBLEMS represent some of the leading equipment which incorporates Blackhawk hydraulic components. Scores of critical designers and buyers recognize that *Blackhawk* hydraulics create exclusive advantages for the engineering, manufacturing, sale and service of their products.

BLACKHAWK HYDRAULIC EQUIPPED

AN EMBLEM REPRESENTING DEPENDABILITY THROUGHOUT INDUSTRY



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YOU ARE INVITED to write for the helpful 24-page bulletin No. 1-B. It describes *"BENEFITS Created for Management, Sales, Engineering and Manufacturing by Blackhawk High-Pressure Hydraulics."* It will bring you helpful suggestions for profitable applications of "Service Proved" hydraulics on original equipment. Blackhawk specializes in a range of hydraulic equipment and services unmatched by any other manufacturer.

"Standards" or "Specials" — Because of continuous production and widespread use, Blackhawk's standard, cataloged pumps, rams and valves *are available from stock at attractive prices.* We also have the engineering and manufacturing facilities to develop and produce hydraulic equipment of special designs. We especially invite your requests for quotation on specialized *ram* requirements.

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See Sweet's Product Designer's File.

COMPLETE HYDRAULIC SYSTEMS—PUMPS (HAND AND POWER-OPERATED), VALVES AND RAMS

NEW ALTITUDE RECORDS in assembly and sales...

...both are "jet-assisted" by AMERICAN PHILLIPS SCREWS

NEW ALTITUDE MARKS IN ASSEMBLY: Savings zoom skyward when American Phillips Screws take over the cost-controls in any assembly operation. *Time-savings alone climb as high as 50%* . . . over old-fashioned, slowpoke, fumble-and-fume slotted screws! Meanwhile spoilage and rejects . . . yes, and lost-time accidents, too . . . are grounded once and for all.

NEW ALTITUDE MARKS IN SALES: Next time you board a commercial airliner . . . or *any* plane, for that matter . . . look around you and see what the aviation industry thinks of American Phillips Screws. *They use almost nothing else but!* And aside from the assembly savings and the vibration-proof fastenings, there's another customer-consideration in there, also . . . because there's never a burr on a Phillips head to snag clothes or scratch hands. Buyers of everything from airplanes to zithers, what's more, are coming to recognize *and look for* the American Phillips crossed recess as a sure surface index of inbuilt quality in *any* product. Does *yours* have this sales advantage? Just write:

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois St. Norristown, Pa. *Detroit 2:* 502 Stephenson Bldg.

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

8 reasons why you should choose Maxi-Power Drives

1. HIGH QUALITY GEARING

Alloy steel gears and pinions with gear teeth generated to greater accuracy. Improved methods of heat-treating give increased strength—longer life.

2. HIGH EFFICIENCY

Antifriction bearings — improved accuracy of gears — maintained accurate alignment —effective lubrication assures operating efficiencies.

3. DEPENDABLE PERFORMANCE

Improved design, rugged construction, highest quality materials, accurate manufacture to close tolerances, all assure extreme ruggedness necessary for heavy-duty service over long periods.

4. SMOOTH OPERATION

The overlapping tooth action of the extremely accurate gears, plus close back lash tolerances, provides smooth, quiet operation.

5. MORE POWER—LESS SPACE

The careful engineering, quality manufacture and the use of finest materials permit the selection of a smaller size unit than was previously necessary.

6. POSITIVE LUBRICATION

All gears and bearings are lubricated from a large oil reservoir by a simple, efficient system. Oil seals at all shaft extensions provide oil-tight construction—clean operation.

7. APPLICATION ADAPTABILITY

Many combinations of shaft assemblies permit a wide variety of arrangements of gear drives between prime mover and driven equipment. Any prime mover may be used.

8. WIDE RANGE OF SIZES AND RATIOS

Single, double, and triple units in a range of 42 sizes. Standard ratios from 2.08 to 1 up to 360 to 1. h.p. up to 1350.

More Power in Less Space

WITH THE NEW MAXI-POWER DRIVES

High quality, rugged dependability characterize this new line of enclosed helical gear drives—Maxi-Power by Foote Bros.

These drives are available in single, double, and triple reductions in a wide range of sizes and ratios.

Mail the coupon for Bulletin or call Foote Bros'. representative in your city.

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Better Power Transmission Through Better Gears

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Dept. W, 4545 South Western Boulevard, Chicago 9, Illinois

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Please send me Bulletin MPA on Foote Bros. MAXI-POWER DRIVES

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Title .....

Company .....

Address .....

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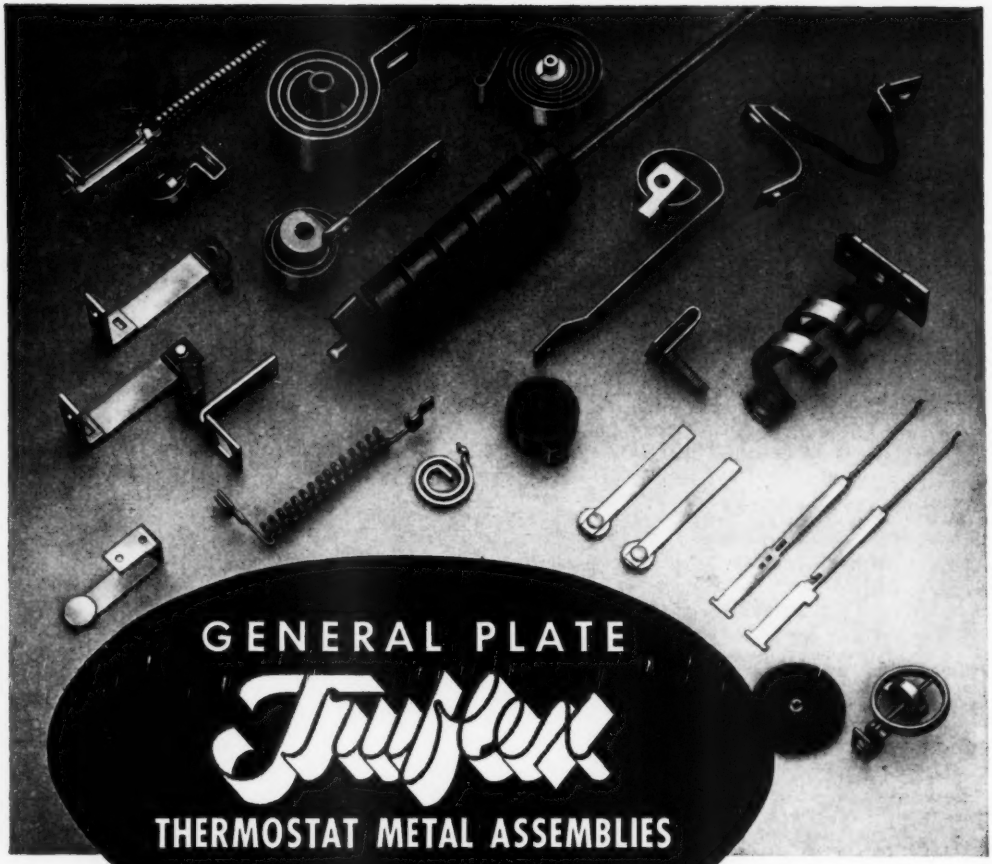

. . . to meet Every Temperature Requirement

If you want to cut costs and get reliable automatic temperature control on practically any type of product, use General Plate Fabricated Truflex Thermostat Metal Assemblies.

You save money because General Plate fabricates, according to your specifications, complete units which are shipped to you ready for instant application. It means you eliminate costly fabrication problems, such as buying new equipment . . . experimental and assembly adjustments are crossed from your books.

You get reliable performance because every order comes to you an exact duplicate of the original . . . consistently uniform in tolerances, temperature reaction and performance, thus preventing rejects and costly adjustments in assembly.

General Plate Truflex Thermostat Metal Assemblies will be made to meet your specification requirements for temperature range, electrical resistance, corrosion resistance, etc. However, if you prefer to make your own assemblies, we will produce strip or coils to your specifications. Write for information or engineering assistance.

CLIP AND SEND THIS COUPON TO US TODAY

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757 West Third St., Mansfield, Ohio Los Angeles, Calif.

GENERAL PLATE
Division of Metals & Controls Corporation
110 FOREST STREET, ATTLEBORO, MASSACHUSETTS

Gentlemen:
Please send me information on Truflex Thermostat Metal Assemblies and raw stock.

Name_____
Address_____

I-949

It's amazing what adhesives can do

Some of the most ingenious applications of modern adhesives do not involve fastening one thing to another. For example, a fast-setting Armstrong Adhesive sprayed on the first few turns of paper tape can replace more costly pre-formed cores.

Other new Armstrong Adhesives are doing remarkable things to simplify fastening methods. It is now possible to attach metal to porcelain, wood to steel, metal to metal, even artificial parts to living human tissues. The possibilities offered by modern industrial adhesives are almost unlimited.

Frankly, we don't know all that Armstrong's Adhesives can do. But if these unusual examples suggest to you that an adhesive might improve your product or simplify your production problem, we'd like a chance to talk it over with you.

Perhaps we already have the adhesive you need. Or possibly your suggestions can guide us in developing an adhesive with the properties you require. Call or write the Armstrong Cork Co., Industrial Adhesives Dept., 6810 Arch Street, Lancaster, Pennsylvania. Available for export.

ARMSTRONG'S ADHESIVES

Made by the makers of Armstrong's Linoleum

IF YOU USE STAINLESS STEEL

here are the results you can get by changing to *Carpenter* Stainless

If you are hard to convince—if you believe that all Stainless Steels of the same Type Number are alike, look at the jobs shown here.

Each of these jobs was first done with the same type Stainless from another source, but look at the savings when the change was made to Carpenter *Free-Machining Stainless.*

The reason for savings like these is uniform free-machining properties in bar after bar of Carpenter Stainless, no matter when you buy it. If you want proof that you can cut costs on Stainless machining jobs, send your next production order to your nearest Carpenter warehouse listed below.

UNIT PRODUCTION UP 15% ON THIS JOB

These small instrument parts are machined to close tolerances: ±.0002" on the diameter, ±.0005" on the length and ±.0003" on concentricity. Several kinds of Type 303 Stainless were used, but unit production per shift went up 15% when the change was made to Carpenter Stainless No. 8 (Type 303).

REJECTS CUT BY ½

You can't afford many rejects on mass production low cost jobs. When this change was made to Carpenter Stainless No. 5 (Type 416), rejects were cut in half and tool life increased 25%.

23,400 BONUS PARTS

Longer tool life, less machine down-time, accounts for 23,400 extra parts per run—and the company saves $456.00 per year on tool re-grinding now that Carpenter Stainless No. 8 (Type 303) is used.

Stainless Machining "Know-How" Is a Help on Every Job . . .

Useful machining information collected in our work with users of Stainless has been put into the 96-page Carpenter "Notebook on Machining Stainless Steels". For your copy, send us a note on your company letterhead, indicating your title. For the men in your plant, additional NOTEBOOKS are available at 50¢ apiece.

THE CARPENTER STEEL COMPANY, 117 W. Bern Street, Reading, Pa.

Carpenter

FREE-MACHINING

STAINLESS STEELS

Now add to the advantages of Carpenter Free-Machining Stainless

***Rush* DELIVERY FROM YOUR NEAREST WAREHOUSE—**

more than corrosion resistance

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Export Department: 233 *Broadway, New York 7, N. Y.* "CARSTEELCO"

ACCURACY!

ZINC DIE CASTINGS GET THE CALL WHEN CLOSE TOLERANCES ARE REQUIRED

TOLERANCES OF ±.002" →

This one-piece master cam for General Instrument's new automatic record changer is a typical example of the dimensional accuracy which can be obtained with ZINC die castings. Not only is this one-piece design extremely complex in shape, with gear teeth and projections accurately cast in place, but the various tracks (indicated at the right) are held to tolerances of ±.002".

FOR EFFICIENT PERFORMANCE →

The three tracks on the cam (shown here in outline) provide three different routes for a sweep lever stud to travel, depending upon the speed of the record being played—33⅓ rpm, 45 rpm or 78 rpm. The sweep lever is an integral part of the tone arm and any movement of the stud in its track is reflected in a corresponding motion of the tone arm head and needle. Hence the need for close tolerances on the track walls.

A combination of many advantages—of which dimensional accuracy is only one—make ZINC die castings the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss these advantages with you. Or write to us

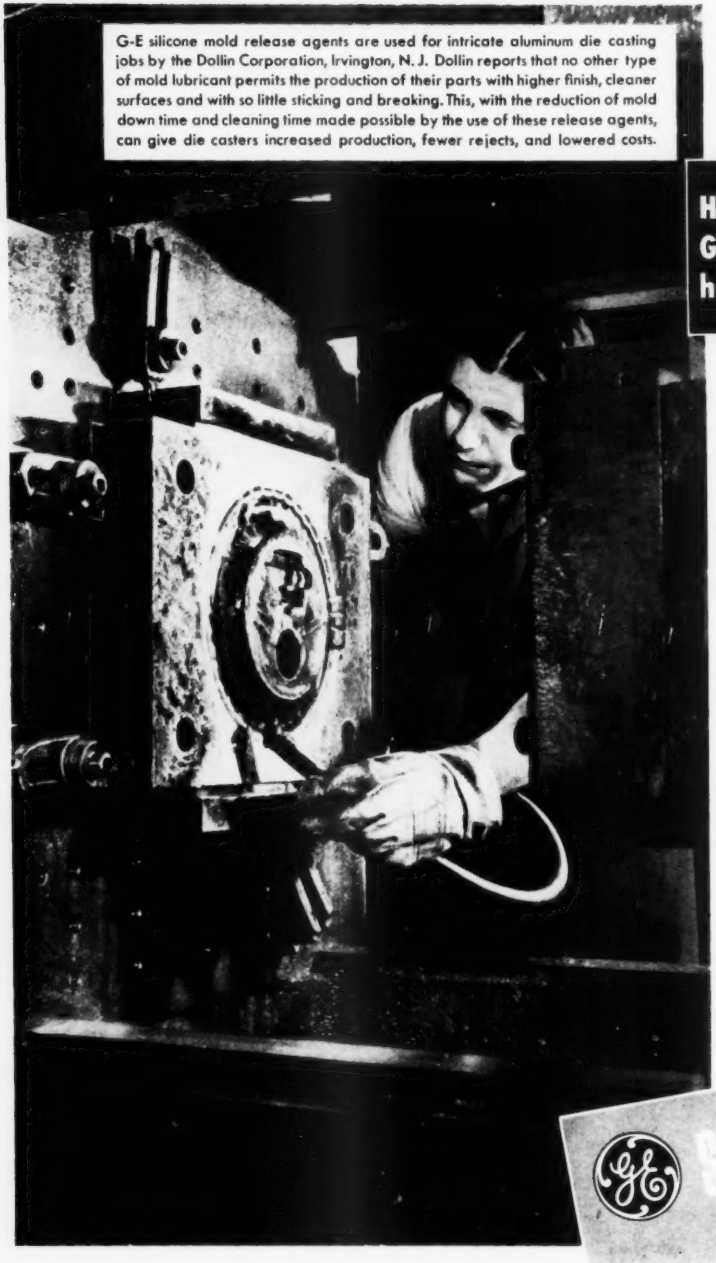
The New Jersey Zinc Company, 160 Front Street, New York 7, New York.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

When the die is cast—use G-E Silicones



G-E silicone mold release agents are used for intricate aluminum die casting jobs by the Dollin Corporation, Irvington, N. J. Dollin reports that no other type of mold lubricant permits the production of their parts with higher finish, cleaner surfaces and with so little sticking and breaking. This, with the reduction of mold down time and cleaning time made possible by the use of these release agents, can give die casters increased production, fewer rejects, and lowered costs.

How can G-E Silicones help YOU?

There are many more uses for G-E silicone products than just as mold release agents, for the chemical inertness, temperature-resistance, and flexibility of these versatile semi-organics make them useful to many industries.

Some of the present G-E silicone applications are: **silicone rubber** for gaskets and insulation; **silicone oils** for mold lubricants, hydraulic systems; **silicone dielectric compounds; silicone resins** for high-temperature electrical insulation and industrial finishes; **silicone water-repellents** (DRI-FILM*); **silicone gums and compounds** for rubber manufacturers.

If you would like to learn more about G-E silicones and what they can mean to you in *your* business, just write to Section 37-10, Chemical Department, General Electric Company, Pittsfield, Massachusetts.

*Reg. U. S. Pat. Off.

SILICONES for Industry

GENERAL ELECTRIC

CD49-Q6

A Wonder Metal Is Being Born

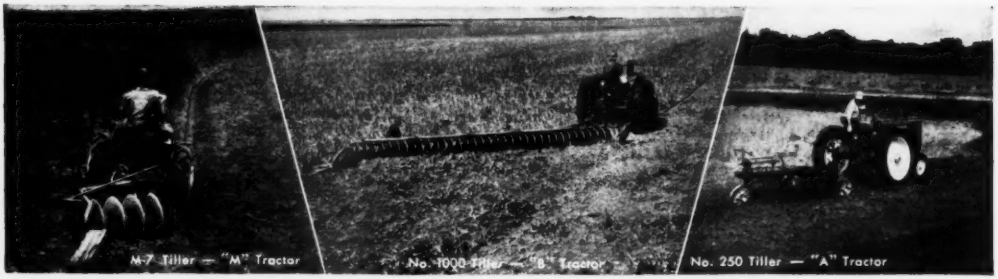
FOR MANY YEARS engineers have been hoping for a metal as strong as steel but only half as heavy. By all indications, the wishes for such a wonder metal will soon be realized in the availability of titanium for commercial applications. In addition to its high strength and light weight, titanium is comparable to gold and platinum in its corrosion resistance, retains much of its strength at temperatures up to about 600 F and possesses a combination of properties and characteristics unmatched by any other known material. Truly, it is a wonderful metal, and one that promises to have a great effect on product designs of the future.

Admittedly, the present prices of titanium prohibit its general use. No titanium alloys have been made other than laboratory samples. However, the rate of progress is amazing. Never before have there been such concentrated and intense efforts made to bring a new material from the laboratory stage to the commercial product. Tens of millions of dollars are being spent by a half a dozen or more companies to hasten the development of titanium alloys and lower the costs to a commercial level. Another five years at the present rate should bring down the cost of the material to a price not too much higher than aluminum, magnesium, and stainless steels. When that has been achieved there will have been opened to product engineers a whole new world of design possibilities.

With material like titanium and titanium alloys, vast improvements will be possible in the design of engines, turbines, and equipment that must be operated at high temperatures. Furnaces and heat exchangers might possibly be vastly improved through the use of titanium because of its amazing corrosion resistance and ability to withstand high temperatures. These same properties of titanium might well result in its use for parts in food processing equipment and chemical and oil refining equipment. Some time in the near future many of our transportation vehicles might well be obsoleted by redesigning them to be made of titanium and its alloys.

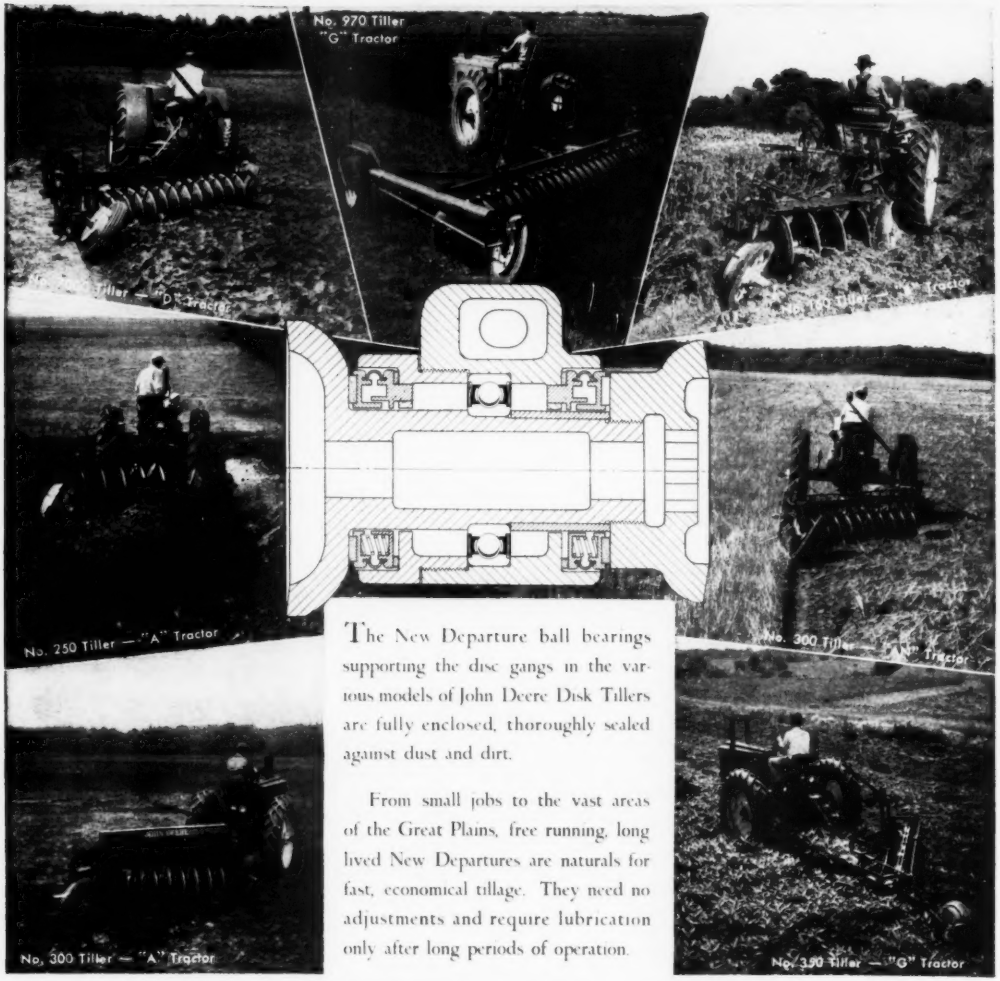
The fact that it will be some years before titanium will reach commercial availability at competitive prices tends to make one ignore this important development. It must be kept in mind that wide awake competitors who keep abreast of the developments might unexpectedly launch improved designs that possess unmatchable features by virtue of the use of titanium. The combination of properties possessed by this new "wonder" metal is not found in any other material. Titanium should be kept in mind in any long range design development program. For a product engineer to ignore the metal might well be a boon to his competitors.

G. F. Rodenhold



Everywhere Disks Turn Freely on New Departure Ball Bearings

nothing rolls like a ball

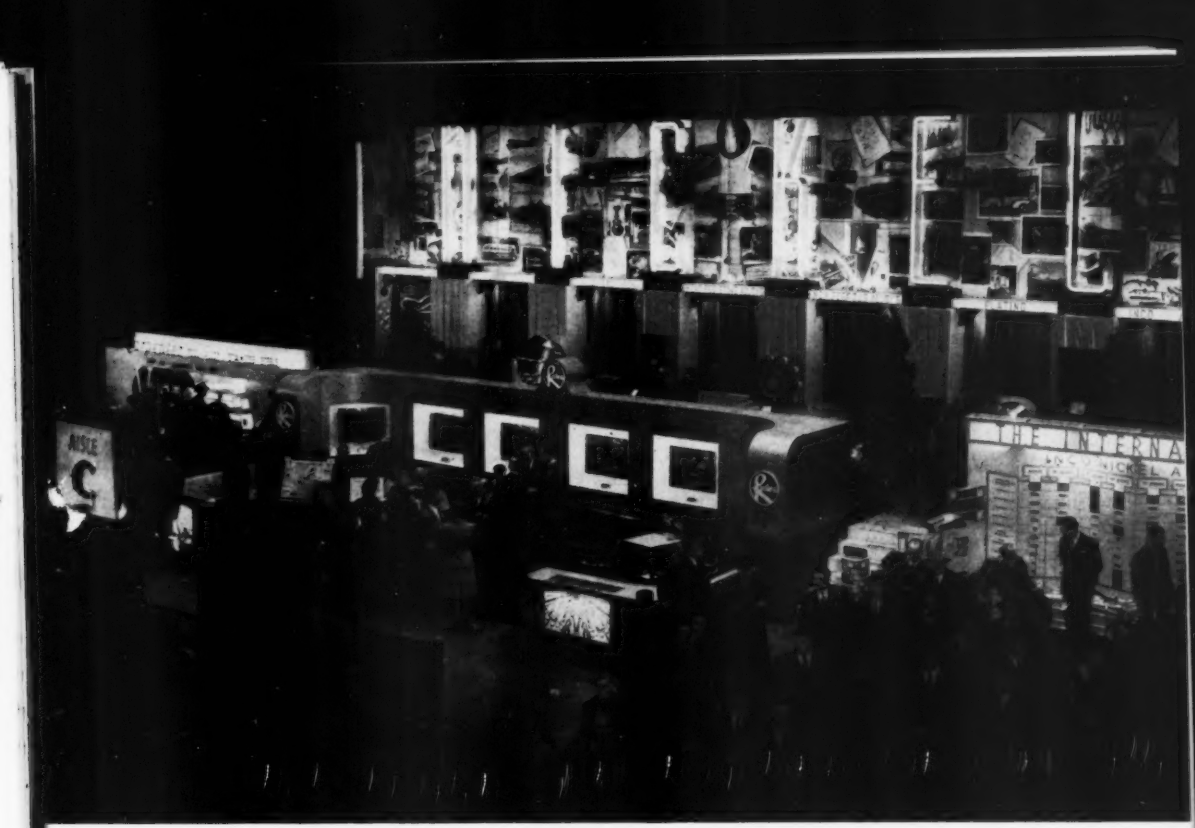


The New Departure ball bearings supporting the disc gangs in the various models of John Deere Disk Tillers are fully enclosed, thoroughly sealed against dust and dirt.

From small jobs to the vast areas of the Great Plains, free running, long lived New Departures are naturals for fast, economical tillage. They need no adjustments and require lubrication only after long periods of operation.

NEW DEPARTURE BALL BEARINGS

NEW DEPARTURE • Division of GENERAL MOTORS CORPORATION • BRISTOL, CONNECTICUT • BRANCHES IN ALL PRINCIPAL CITIES



Economy—Theme of THE METAL SHOW

ACKNOWLEDGING THE GENERAL TREND toward cost reduction throughout industry, the four technical groups sponsoring the 31st National Metal Exposition and Congress have chosen the theme "Economy in Production."

More than three hundred companies in the metals, processing and test equipment fields have reserved space in Cleveland's Public Auditorium for the five-day show starting October 17th. Concurrently, 200 technical papers arranged by the American Society for Metals, American Welding Society, Metals Branch of the American Institute of Mining and Metallurgical Engineers and the Society for Non-Destructive Testing will be presented on subjects covering different aspects of this same timely subject—economy.

Round table discussions and technical sessions on alloy steels, oxidation, quenching, high temperature metallurgy, temper brittleness and atomic energy metallurgy will highlight the ASM congress. AWS sessions will cover hard facing, flame hardening, resistance welding, welding of aluminum, arcs and electrodes, inert gas welding and gas cutting.

President-elect of the American Society for Metals is Arthur E. Focke, Research Metallurgist, Diamond Chain Company.

Each exhibit at the Show will emphasize the economies that can be realized through the application of new materials, processes and equipment or by putting existing materials and methods to more efficient use.

New alloys with improved heat, corrosion and wear resistance; new or refined fabrication processes and new test and quality control equipment—all will mean improved product quality at reduced cost. The seven pages that follow highlight the more significant developments that will be displayed in the exhibits at the Show.

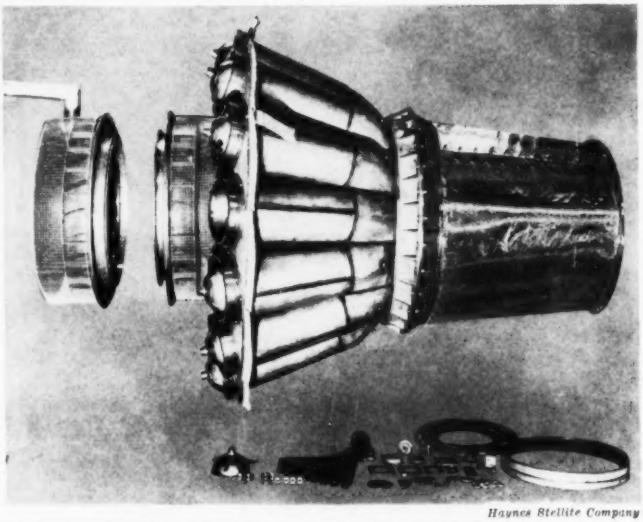
High Temperature Alloy Easily Cold Worked

HAYNES STELLITE COMPANY will add a new alloy, Haynes L-605, to their line of high temperature, corrosion and abrasion resistant materials. L-605 has outstanding cold working and welding characteristics in the 1,700 to 1,800 F range. Reports are that drop hammer, deep draw and similar forming operations can be carried out as readily with the new material as on some stainless steels.

Composed of 50 Co, 20 Cr, 15 W and 10 Ni, the L-605 alloy has applications in turbine blades, combustion chamber liners, inner and outer cones and exhaust stacks for jets.

Average Short-Time Tensile Properties of L-605 Sheet
(0.040 in. thick, annealed at 2,200 F)

Test Temp., deg F	Ultimate Str., psi	Elongation, % in 2 in.
1,200	74,500	25.0
1,500	50,000	15.0
1,800	22,700	16.0
2,000	13,950	23.3



Haynes Stellite Company

Combustion chambers made of Haynes L-605 corrosion and abrasion resistant alloy withstand flame impingement and buckling at temperatures up to 1,800 Fahrenheit.

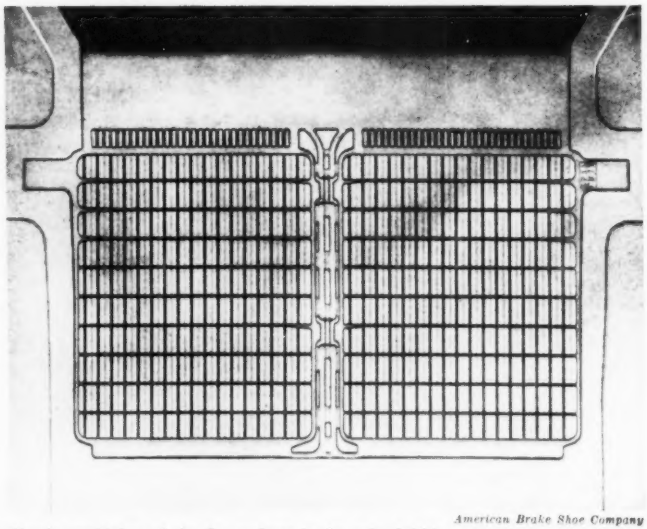
Process Refinement Results in Super-Precision Castings

AMERICAN BRAKE SHOE will display precision castings produced by a new method—a development of real significance to the foundry industry.

Starting where investment molding leaves off, castings ranging in weight from one pound to one ton, have an eggshell-smooth surface and tolerances down to 0.005 inch. A mold for storage battery plates that previously required considerable machining, sinking of the cavity and stippling now needs only a simple finish grind.

The Electro-Alloys Division will feature their new Thermalloy HC-250, a high-chrome alloy that is highly abrasive and wear resistant, is machinable in the annealed state yet is hardenable to 650-750 Brinell and is not oxidized at 1,800 F temperatures.

American Forge Division will show forged steel aircraft starter housings in which the amount of carbon steel required has been appreciably reduced through redesign. The original solid forging weighed 36¾ lb, required 49 lb of stock. The redesigned housing weighs 21¾ lb, uses only 28 pounds.



American Brake Shoe Company

Simple machining of the flat surfaces is the only finishing operation required after casting this alloy-iron mold for automotive storage battery plates.

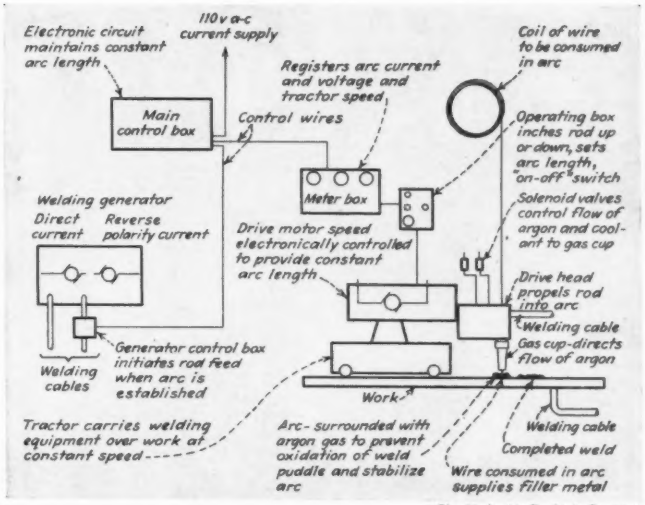
Metal-Arc Welder Is Fully Automatic

AUTOMATIC EQUIPMENT for making argon-shielded metal-arc welds in aluminum will be demonstrated by The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation. The advantages of the process are the production of smooth, spatter-free welds in thick material at high speed without the use of flux.

Butt, fillet and lap welds can be made in material from $\frac{3}{16}$ in. to $1\frac{1}{2}$ in. thick. Arc speeds are varied over a wide range. Coiled welding rod of $\frac{3}{32}$-in. dia is used; arc current is about 260 amperes.

An electronic control maintains a constant arc length by varying the speed of the rod feed motor. Operating controls include push buttons for inching the welding rod in threading it through the driving gear, an arc-length control knob and an "on-off" switch.

A carbon pencil is used to strike the arc between the rod and the work. As the arc is struck, the surge of current closes a relay that starts the rod feed and carriage travel motors.


110v a-c current supply
Electronic circuit maintains constant arc length
Main control box
Control wires
Registers arc current and voltage and tractor speed
Coil of wire to be consumed in arc
Operating box inches rod up or down, sets arc length, "on-off" switch
Meter box
Solenoid valves control flow of argon and coolant to gas cup
Welding generator
Direct current
Reverse polarity current
Drive motor speed electronically controlled to provide constant arc length
Drive head propels rod into arc
Welding cable
Gas cup-directs flow of argon
Generator control box initiates rod feed when arc is established
Welding cables
Work
Tractor carries welding equipment over work at constant speed
Arc-surrounded with argon gas to prevent oxidation of weld puddle and stabilize arc
Welding cable
Completed weld
Wire consumed in arc supplies filler metal

The Linde Air Products Company

Schematic layout of Linde argon-shielded metal-arc welding machine. Electronic controls maintain proper arc length by keeping arc voltage constant.

Zinc Die Castings Reduce Total Cost

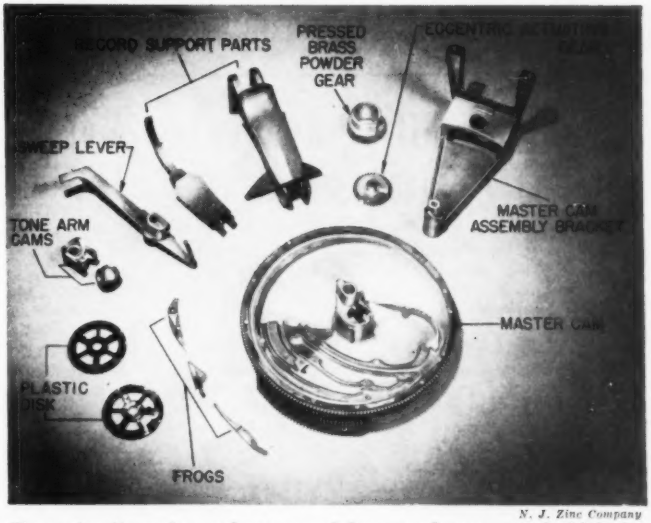
NEW JERSEY ZINC will display a large selection of recently marketed products in which die castings and metal powder parts are used to simplify operation and assembly, yet still make possible large cost reductions.

A complete section of the 1949 Oldsmobile from the windshield forward will demonstrate the wide applications of zinc die castings—most of the trim both inside and out as well as many parts of the engine.

General Instrument's new automatic record changer that handles all three speeds and record sizes will be in action. Eleven zinc die castings and one pressed-brass powder gear are included in the intricate under-carriage mechanisms.

Only four die cast parts make up a semi-universal washing machine pump. Appliance Engineering Company is mass producing these assemblies at a cost well below that of earlier designs.

Other applications include a washing machine pump and wringer head, a cigarette vending machine and a locking door handle.



N. J. Zinc Company

Eleven zinc die castings and one pressed brass powder gear permit fabrication economies in drive mechansim of all-speed record changer.

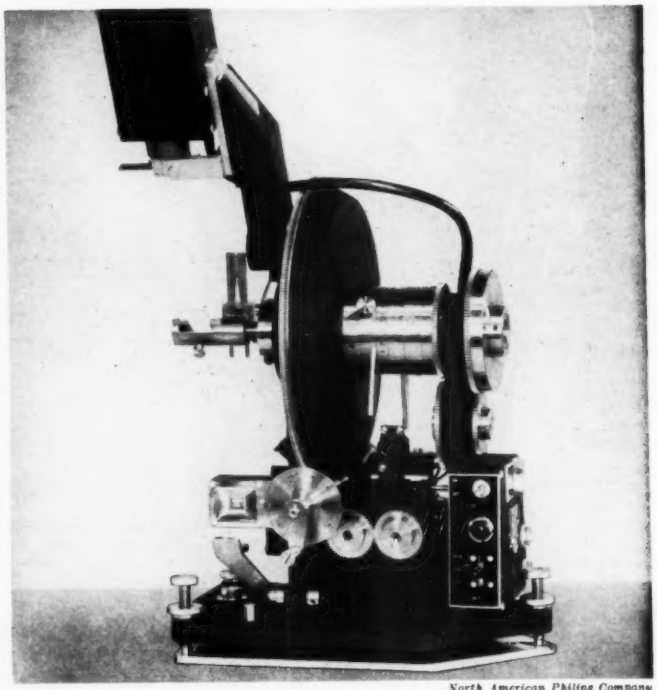
Wide-Angle Spectrometer Aids Process Control

NORTH AMERICAN PHILIPS will present a wide-angle Geiger-counter X-ray spectrometer of new design. Vertical scanning over a wide range from —38 to 160 degrees is possible yet specimens can be mounted horizontally. Instrument incorporates the close tolerances necessary for exact determination of the locations and intensities of X-ray reflections.

While the specimen is rotated within the X-ray beam at a preselected angle, the gear-driven Geiger counter turns twice as fast as the specimen so that diffracted beams are picked up at all angular positions. A special focusing system limits angular divergence and improves image resolution. Angles are indicated directly to one one-hundredth of a degree.

Equipment operates in conjunction with a high-output, water-cooled, X-ray tube energized from a full-wave rectified power supply. Unit can be placed on or removed from the X-ray source, thereby increasing utility and flexibility of the X-ray generator.

Process control economies result when two of these instruments are operated simultaneously from a single X-ray tube. The duty factor is therefore multiplied and the cost per hour of operation reduced for each unit. One or more cameras and electronically controlled recording devices can be used in plotting image patterns.



North American Philips Company

Wide-angle Geiger-counter spectrometer incorporates close tolerances needed for exact determination of positions and intensities of X-ray reflections.

New Nickel-Silver Rod For Gas Welding

WELDING AND BRAZING with nickel-silver rods of thin sheet steel by the shielded arc method will be the highlight of the American Brass Company exhibit. In addition, duplex tubes having inner and outer walls of different materials and condenser sheets of Muntz metal drilled for these tubes will be shown.

Welding rod No. 828—46.50 Cu, 43.38 Zn, 10 Ni, 0.10 Si, 0.02 P—provides a reasonably good match with silver-colored parts. It produces high-strength welded joints in steel or cast iron at welding temperatures of 1,690 Fahrenheit. Material performs best in oxy-acetylene welding or brazing operations, is not suitable for arc welding.

Everdur rod No. 1010—96 Cu, 3.0 Si, 10 Mn—will also be demonstrated. Copperish in color, material can be used in inert-gas, shielded-arc welding process. Melting point is 1,870 Fahrenheit.

Motor Commutator Is Simple to Fabricate

REVERE COPPER AND BRASS will exhibit applications of copper, brass, nickel-silver and aluminum to products in the automotive, aviation, electrical and home appliance fields. Demonstration samples of copper applications include phonograph record molds in which groove detail is especially precise, automotive radiator cores, refrigerator dehydrator elements and small electric motor commutators.

In the latter application, oxygen-free, high-conductivity copper sheet is stamped and rolled to form the cylindrical shell on a multi-slide machine. A tough, insulating plastic is molded around bent projections within one end of the shell. The commutator segments are then formed by sawing a series of parallel slots in the shell to a depth equalling the thickness of the copper. Tolerances of 0.001 in. are held on the diameter and length of the shell.

Mass Checking of Parts Cuts Inspection Costs

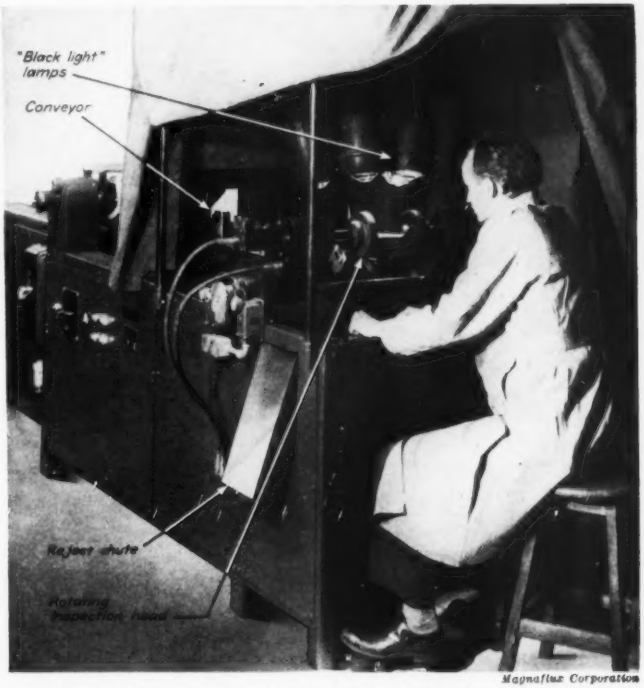
MAGNAFLUX CORPORATION will show off their MA-3 inspection equipment for automotive forgings. Unit is designed to handle a variety of differently-shaped parts — connecting rods and steering gear components such as spindles, arms and supports.

Machine processes a maximum of 1,200 parts per hour, allows rapid but complete inspection of all surfaces subject to defect. Change-over time from one type of part to another varies from 15 to 30 minutes.

Parts are loaded on conveyor fixtures and carried between magnetizing heads where they are clamped. A 300-amp, low voltage alternating current is applied to induce a circular magnetic field in the part. The conveyor then carries the parts through a hood where fluorescent-dyed ferrous particles suspended in a light oil are sprayed on all surfaces.

In the next step, parts are carried to the inspection booth, where they are clamped, removed from the conveyor fixtures and rotated for inspection under near ultra-violet lights. This "black" light causes any formed indications to glow brilliantly by activating the fluorescent dye in the particles as the parts rotate.

Acceptable parts are automatically directed from the tilted tray to one side and fed through a demagnetizing coil. Rejects are dropped out the other side when a foot switch is depressed.



Inspection machine rotates 1,200 forgings per hour in "black" light. When defects appear, operator presses foot switch to reject part into chute.

Versatile Shape Cutter Is Moderately Priced

AIR REDUCTION SALES CORPORATION will take the wraps off a new shape-cutting machine. The Airco No. 3 Monograph is a portable, oxyacetylene unit that cuts stock up to 8 in. thick, 32 in. wide and 56 in. long. By adding 80-in. track sections, the cutting area can be extended as desired. In addition to simple cutting jobs, the equipment can also handle bevel work. Torch, tip, manual tracing device and a carrying case are included in the selling price of 695 dollars.

Second item of interest will be the Aircomatic gas-shielded metal arc welding process introduced at the 1948 Metal Show. Significant feature is the adoption of the process to stainless steel. Previously, aluminum was the only metallic wire that could be fed through the manually-operated gun.

According to Airco, stainless can be welded in all standard joint designs in thicknesses of $\frac{1}{8}$ inch.

New General-Purpose Aluminum Alloy

THE ALUMINUM DIVISION, Permanante Products Company, will stress their new 150S aluminum alloy. Compared to the 3S composition, 150S has 20 to 40 percent greater strength in the finished part, uniform grain size in all tempers, uniform etched surfaces, clear anodized finishes, high lustre buffing and good workability.

Tensile Properties of 150S Aluminum Alloy

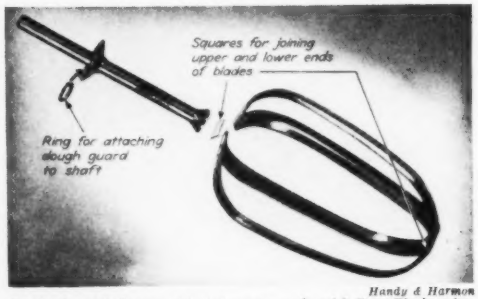
Temper	Tensile Str., psi	Yield Str., psi	Elongation, % in 2 in.
150SO	21,000	8,500	25
150SH22	23,500	16,500	13
150SH32	25,500	21,000	9
150SH34	28,000	24,500	6
150SH18	33,000	31,000	4
150SH19	37,000	35,000	3

Low-Temperature Silver Brazing Alloys

HANDY & HARMON will feature silver brazing alloys that have relatively low melting points. Sil-Fos alloy—copper, phosphorous and 15 percent silver—flows at 1,300 F, provides ductile leak-tight joints on copper, brass, bronze and other non-ferrous alloys. Easy-Flo—copper, zinc, cadmium and 50 percent silver—melts at 1,160 F, joins metals having melting points above this figure and is particularly effective when joining dissimilar metals.

These alloys are adaptable to a variety of heating methods including torch, furnace, induction, gas-air and electrical resistance. Application can be by hand or by preplacement in the form of rings, washers and pieces of flat sheet.

Proven applications of these brazing alloys include frames for chain saws, moldings for automobile windows, motorcycle crankshafts, hydraulic shock struts for airplane landing gears, copper dampers in large generators.



Handy & Harmon

Food mixer blade assembly joints are made with Easy-Flo brazing alloy ring and squares at rate of 12,000 per day.

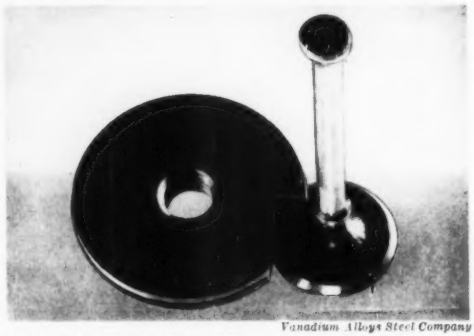
Machining Speeds Increased With New Steel

VANADIUM ALLOYS STEEL COMPANY will spotlight a new ultra high speed steel—Vasco Supreme. Machining speeds 15 to 100 percent higher and wear resistance several times greater than other tool steels result in longer production runs and more pieces per grind. Five percent cobalt in addition to 1.5 C, 12.5 W, 4.75 Cr and 5.0 V is the main difference when compared with other compositions.

The working hardness of Vasco Supreme is 65-67 Rockwell C; its quenching and tempering temperatures 2,200 F and 1,050 F, respectively.

The machining of SAE 52100 bearing races exemplifies the improved performance gained with Vasco Supreme as the tool material. Previous cobalt steel tools averaged 667 pieces per grind at a speed of 75 sfpm. Tools made of the new alloy average 1,937 pieces at 94 surface feet per minute.

A Vasco Supreme spline broach used on cast iron gears, has a record of 80,200 pieces. The life of previous broaches made of 18-4-1 high speed steel is 10,000 gears.



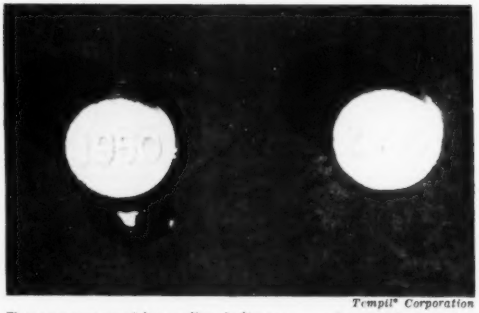
Vanadium Alloys Steel Company

Cobalt high-speed steel forming tool cuts shoulders of SAE 2112 exhaust valves at rate of 1,985 units per grind.

Range of "Temperature" Sticks Expanded

THE TEMPIL® CORPORATION will show their expanded line of temperature indicating sticks and pellets. Working temperatures up through 2,000 F can be controlled to within one percent of actual value. Fifty-six different sticks and pellets are available starting at 113 Fahrenheit. Critical temperatures are at 12-deg intervals up to 400 F, at 50-deg intervals above this figure.

Control of preheat for welding as well as post-heat for stress relief, flame cutting, tempering, forging, casting, molding, drawing, straightening, heat-treating in general, and other applications are now possible.



Tempil® Corporation

Temperature-sensitive pellet indicates material ambient is between 1,950 and 2,000 Fahrenheit.

New Nickel Alloy For High Temperature Uses

INTERNATIONAL NICKEL will display Inconel "X", the latest of a series of age hardenable alloys. Outstanding property is high strength under sustained or cycled stress at temperatures ranging from sub-zero to 1,500 Fahrenheit. The metal is well suited for use in rocket motor assemblies, gas turbine rotor blades and testing machine grips.

Short time tensile strength of 0.05-in. Inconel "X" sheet annealed and aged is 160,000 psi at room temperature. The directly aged material retains 90 percent of tensile and yield values up to 900 F, and 80 percent up to 1,100 Fahrenheit. Where the material is solution-treated and aged, the yield strength at 1,100 F is 90 percent of room temperature value.

Nominal composition of Inconel "X" is 70 Ni, 15 Cr, 2.5 Ti, 7.0 Fe, plus traces of several other elements.

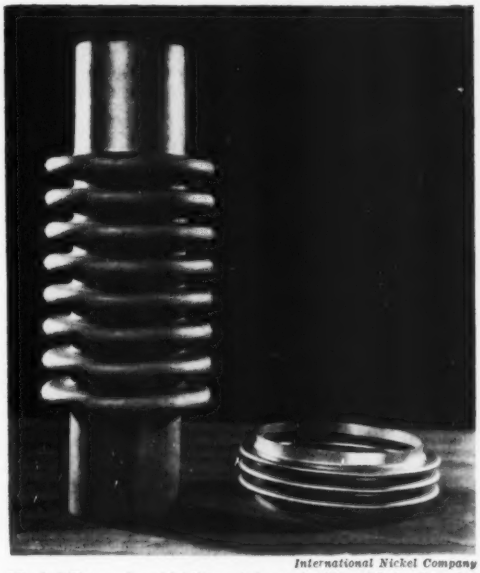
The alloy is particularly useful where corrosive or oxidizing conditions exist in highly stressed parts. If the temperature encountered is at or above 1,100 F, full heat treatment must be applied; while the combination of cold working with heat treatment gives higher strengths at temperatures below 900 Fahrenheit.

Large sections require a stress-equalizing anneal before aging. Material so treated has better ductility than when directly aged, yet there is little loss of strength. Equalizing and aging and also directly aged material is for applications up to 1,100 Fahrenheit. For applications above 1,500 F, the effect of age hardening is lost and the alloy is then used in the annealed condition.

The metal is made in the form of billets, tubes, rods, springs, bolts, wire and sheets; can be easily welded, machined and forged, but not cast. Nearly all commonly used welding methods are applicable.

Inconel "X" Sheet and Strip
Range of Room Temperature Properties for Mill Production
Gages 0.025 to 0.250 inch

Property	Annealed	Annealed and Aged
Tensile strength	100,000–140,000	150,000–175,000
Yield strength 0.2 percent offset, psi	40,000–80,000	100,000–130,000
Percent elongation in 2 inches	35–60	20–30
Hardness, Rockwell	77–100B	30–40C
Specific heat—room to 212 F	0.10–0.11	
room to 1,652 F	0.13	
Magnetic permeability	1.0028	
Melting point, F	2,540–2,600	
Density, lb per cu inch	0.3	
Specific gravity	8.3	



International Nickel Company

Workability and weldability of Inconel "X" nickel alloy for high temperature use is exemplified by exhaust system expansion joint for jet engines. Single weld runs full length of part.

Electrode Selector Lengthens Life of Welders

METAL & THERMIT CORPORATION will demonstrate their expanded line of arc welding machines in which simplicity of current control is the special design feature. Separate plug-in connections are provided, one for each size electrode that is used with a particular machine. Burning and corroding of contact points, characteristics of the rotating type selector switches, are greatly reduced, providing longer life of parts.

Capacities of the welders range from 150 to 400 amp for d-c motor-generator sets, 200 to 400 amp for gasoline engine driven d-c sets.

Automatic Control For Speed Changers

REEVES PULLEY COMPANY will have a new hydraulic control for their variable speed transmissions.

The control consists of a piston and valving assembly that replaces the hand-operated adjusting wheel. Movement of actuating linkages through an arc up to 50 deg permits variation of output speeds.

Advantages of the control are synchronization of different machines or separate sections of a single machine, maintenance of constant tension and uniform winding speeds and control of uniform pressures, weights, liquid levels and temperatures.

Silicon Bronzes Solve Corrosion Problems

BRIDGEPORT BRASS will discuss the design aspects of Duronze silicon and aluminum bronze alloys that exhibit high strength and effective corrosion resistance in a wide variety of applications. Combinations of these materials with other metals, both ferrous and non-ferrous, in the form of Duplex tubing will also be featured.

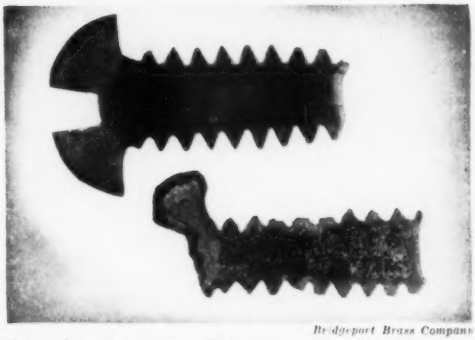
Five grades of Duronze containing tin, silicon, aluminum and arsenic, in addition to copper, fill many uses where properties such as tensiles to 100,000 psi, extreme malleability, toughness, hardness up to Rockwell B 90, machinability or workability are of prime importance.

Graphic example of material replacement is the cold-headed, roll threaded faucet screw illustrated. Impurities in water caused dezincification of the yellow brass (62 Cu, 38 Zn) corroded part. Undamaged part is an alloy of 98 Cu, 2.0 Si that had same period of service as first screw.

Outer surface of the dual metal tubing can be low carbon steel, aluminum, Monel or stainless; inner material can be copper, brass, silicon or aluminum bronze. Applications are heat exchangers and processing equipment.

Mechanical Properties of Duronze II Strip Compared to Phosphor Bronze and Copper

Property		Duronze II	Phosphor Bronze (Grade A)	Copper (Electrolytic Tough Pitch)
Tensile strength, psi	Hard	94,000	81,000	50,000
	Soft	60,000	50,000	34,000
Yield strength, psi	Hard	58,000	75,000	45,000
	Soft	25,000	21,000	11,000
Elongation, percent in 2 in.	Hard	8	10	6
	Soft	60	52	45
Rockwell hardness	Hard	B93	87	B50
	Soft	F85	77	F45



Bridgeport Brass Company

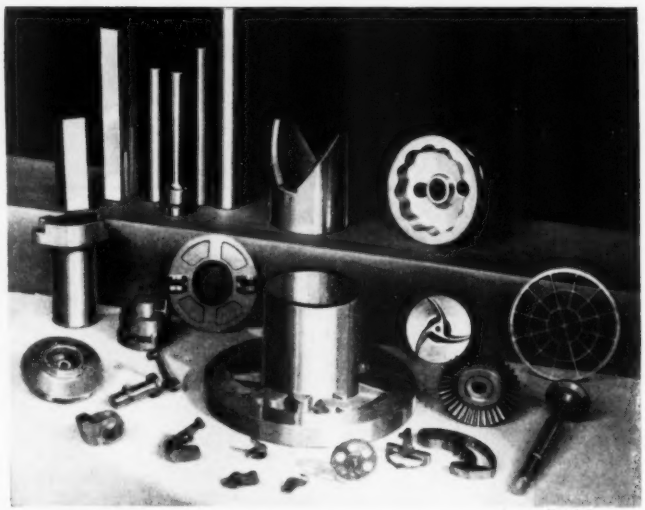
Yellow brass faucet screw (below) and silicon bronze counterpart (above) after one year in contact with well water.

Vacuum Die Cast Aluminum Bronzes Economical

VACUUM DIE CAST Aur-O-Met alloys and their recent applications will highlight the Aurora Metal Company booth. These aluminum, aluminum nickel and silicon bronzes have tensile strengths ranging from 55,000 to 120,000 psi, high corrosion and abrasion resistance, and desirable shock load characteristics. Increased strength with reduced weight and machining make possible overall cost savings.

A 7-lb milk bottle capper body formerly sand cast from German silver was redesigned as a die casting of aluminum bronze alloy (89 Cu, 9.8 Al, 1.0 Fe). New part has tensile strength of about 80,000 psi and a hardness of approximately Rockwell B90. Material is heat treated to 1,675 F, soaked, quenched and then drawn at 950 Fahrenheit. Costs of material and machining were reduced, resistance to lactic acid was increased, linear dimensional accuracy held to half of one percent.

Production costs of a 6-oz gun sight were reduced 77 percent by changing from brazing to vacuum casting.



Aurora Metal Company

Vacuum die cast bronze alloy parts have linear dimensional accuracy down to half of one percent, vary in weight from a fraction of an ounce to 38 pounds.

Inland Steel Company

RAILROAD CAR FRAME is welded of channels, angles and plates of a low alloy steel. Because of their low carbon content, low alloy steels do not require special handling. Use of this material results in less deadweight and more payload capacity.

High Strength, Low Alloy STEELS

Staff Report—Production of high strength, low alloy steels, low in carbon content, with high elastic properties (ductility and yield point) in the as-rolled or as-annealed condition, good forming and welding properties, improved corrosion resistance in certain environments, and high strength-weight ratio, has expanded greatly in recent years.

A NEW GROUP OF STEELS with enhanced mechanical properties and fabricating characteristics has been developed in recent years. Representing an optimum balance between the valuable properties of high alloy steels and the low cost of mild carbon steels, these materials are known as "high strength, low alloy" steels. Commercial compositions are listed in Table I, and usually contain, in addition to carbon, phosphorus, sulfur and manganese, three to five of the following elements: Silicon, copper, nickel, chromium, molybdenum, zirconium and aluminum. Total alloy content varies from 2 to 4.5 percent.

In general, these steels provide: (1) High strength in the hot rolled condition, permitting weight reduction in many designs; (2) adequate ductility to obtain satisfactory fabricating performance with standard equipment; (3) increased resistance to atmospheric corrosion; (4) improved notch toughness; (5) higher fatigue strength; (6) good weldabil-

Table I—Compositions of Typical High Strength, Low Alloy Steels*

Trade Name and Manufacture	Composition, percent										
	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Zr	Al
Aldecor Republic Steel Corp.	0.12 max.	0.15–0.40	0.08–0.15	0.05 max.	0.35–0.75	0.35–0.60			0.16–0.28		
Cor-Ten Republic Steel Corp., United States Steel Corp.	0.12 max.	0.20–0.50	0.07–0.15	0.05 max.	0.25–0.75	0.25–0.55	0.65 max.	0.50–1.25			
Double Strength Republic Steel Corp.	0.12 max.	0.50–1.00	0.04 max.	0.05 max.		0.50–1.00	0.50–1.10		0.10 min.		
Hi-Steel Inland Steel Co.	0.12 max.	0.50–0.90	0.050–0.120	0.05 max.	0.15 max.	0.95–1.30	0.45–0.75		0.08–0.18		0.12–0.27
Mayari-R Bethlehem Steel Co.	0.12 max.	0.50–1.00	0.08–0.12	0.05 max.	0.10–0.50	0.50–0.70	0.25–0.75	0.40–1.00			
N-A-X High Tensile Great Lakes Steel Corp.	0.08–0.15	0.50–0.75	0.04 max.	0.05 max.	0.60–0.90	Resid.	Resid.	0.50–0.65		0.05–0.15	
Yoloy HS Youngstown Sheet and Tube Co.	0.15 max.	0.75 max.	0.100 max.	0.05 max.	0.30 max.	0.75–1.25	1.50–2.00				
For Comparison:											
Mild Carbon (SAE 1019)	0.19	0.85	0.045 max.	0.05 max.							
Deep Drawing Carbon Steel	0.06	0.30	0.010	0.025							

* These do not represent all of the commercial compositions available in this class of steels.

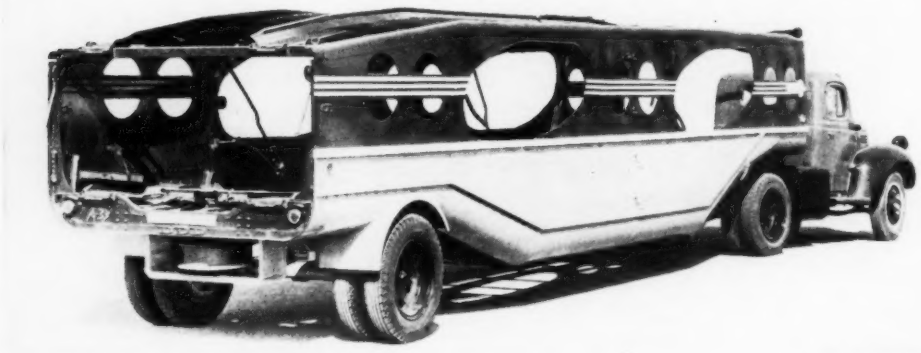
ity; (7) improved abrasion resistance.

Steels of this type, often called "high strength steels", have been given the designations SAE 950 and ASTM A242, and are normally furnished in hot rolled, normalized or annealed condition to minimum static mechanical properties of 50,000 psi yield strength and 70,000 psi tensile strength (see Table II). These steels are intended for use without further heat treatment except for preheating, post heating or stress relieving operations which are sometimes used in conjunction with metal-arc welding of heavy sections. These steels can be purchased in any of the standard shapes or forms normally available in carbon steel. Because of their improved properties and low cost, they have been found particularly advantageous in many types of structures such as mobile equipment.

Corrosion Resistance

Use of thinner sections which are allowable with the low alloy steels might be of no advantage to designers if life was determined by corrosion and if these thinner sections rusted as fast as mild carbon steel. Fortunately, however, the atmospheric corrosion resistance of the low alloy steels is high enough to more than compensate for the reduced cross-section thickness.

Atmospheric corrosion resistance of most of the low alloy steels is from 4 to 6 times that of mild carbon steel, and from 2 to 3 times that of copper-bearing steel (0.17 to 0.27 percent Cu). Of course, atmospheres vary greatly in their corrosiveness; inland



United States Steel Corp.

WEIGHT SAVING of one ton in every unit is made possible by use of low alloy steel in construction of trailer bodies. Redesigning structure with thinner sections throughout resulted in 44 percent more bodies from same total tonnage of steel.

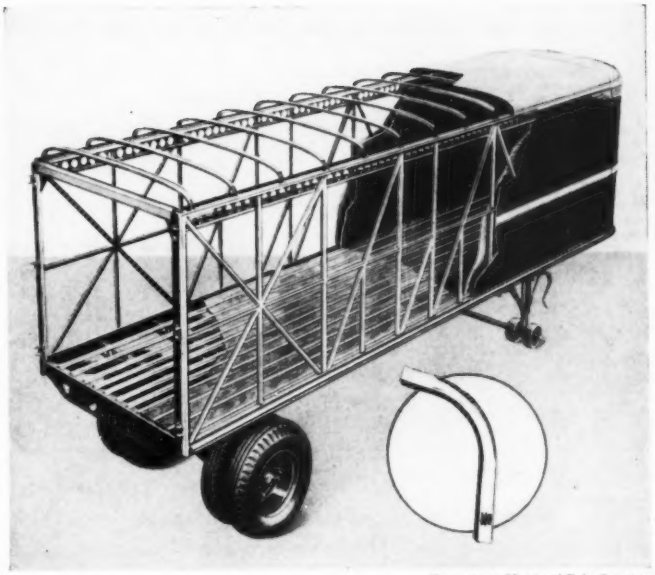
rural atmospheres are milder than industrial or marine atmospheres; industrial atmospheres themselves vary according to degree of contamination; dry inland atmospheres are the least corrosive. However, low alloy steels exhibit only $\frac{1}{2}$ to $\frac{1}{3}$ the weight loss of copper bearing steels, and $\frac{1}{4}$ to $\frac{1}{6}$ the loss of plain carbon steel; this superiority is more pronounced in the more corrosive atmospheres. Also, there is much less tendency for pitting or localized corrosion to occur, this being particularly serious in low copper steels and open hearth irons.

In structures subjected to particularly severe corrosive action, length of life may become more important than weight reduction. By using low alloy steel sections of the same size as plain carbon steel, life of the structure is greatly increased and maintenance costs reduced. Also, where equal sections are used, the low alloy steel section could corrode to a much greater extent without impairing its safety.

This improved corrosion resistance is of prime importance in lightweight mobile structures exposed to severest corrosive atmospheres and having surfaces—such as the inside of a hopper car or a dump truck body—which can not be painted periodically to give added surface protection. In coal car service after approximately six years, the relative corrosion rates based on loss in weight was 1.0 for a low alloy steel (nickel-copper), 1.73 for copper-bearing steel (0.25 percent min Cu), and 2.15 for mild carbon steel. Subsequently, cars made of mild carbon and copper-bearing steels had to be replaced, while after twelve years service the low alloy steel had considerable service life remaining.

Low alloy steels are also useful where corrosion resistance is of secondary importance to strength: In lightweight mobile structures subject to less severe corrosive atmospheres—such as agricultural equipment—or having surfaces that can be painted periodically—such as truck trailers. An interesting fact in this connection is that paint lasts longer on low alloy steels. The accompanying chart indicates that the life of iron oxide paint is approximately 40 percent longer on a low alloy than on a plain carbon steel. When galvanized, low alloy steels can be given a greater coating thickness than mild steel. In many applications, such as hot water tanks and refrigerator car parts, this phenomenon is put to economical use.

Some low alloy steels also have outstanding resistance to combustion gases at relatively high temperatures. Tests on automobile mufflers and similar applications show life increases of



Youngstown Sheet and Tube Company

FRAMEWORK MADE OF LOW ALLOY STEEL increases carrying capacity of Fruehauf van trailer, by eliminating deadweight. Cutaway view shows construction using roll-formed sections of low alloy steel, which combines lightweight with strength.

Table II—Minimum Properties of SAE 950 Steel

(As furnished by the mill)

Thickness or Diameter, in.	Up to 0.0709 incl.	0.0710 to 0.2299 incl.	0.2300 to 1/2 incl.	Over 1/2 to 1 incl.	Over 1 to 2 incl.
Yield point[1], psi min	50,000	50,000	50,000	47,000	45,000
Tensile Strength[1], psi min	70,000	70,000	70,000	67,000	65,000
Elongation[2] in 2 in., percent	30	22[3]	22	22[4]	22[4]
Elongation[5] in 8 in.	.....	.....	1,500,000/tensile strength		
Bend Test[6], 180 deg.	D = 1T	D = 1T	D = 1T	D = 2T	D = 3T

[1] For severe cold forming operations requiring greater ductility, some relaxation of the yield point and tensile strength requirements may be allowed on agreement between producer and purchaser.

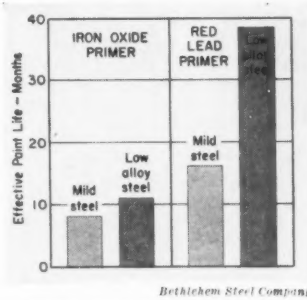
[2] ASTM standard rectangular specimen 2 in. gage length. (ASTM E8.)

[3] For plates, see Note 5. (Minimum thickness for plates over 48 in. wide is 0.180 in.)

[4] Where 0.505 diameter, use ASTM standard round specimen 2 in. gage length. (ASTM E8.)

[5] Plate material 0.180 and heavier is customarily tested in 8 in. gage length using ASTM standard rectangular specimen subject to modification of ASTM A242. (ASTM E8.)

[6] ASTM A242.



Bethlehem Steel Company

LONGER LIFE OF PAINT is indicated in this comparison weathering test of primer paints on low alloy and mild carbon steels. Life of iron oxide paint on low alloy steel is approximately 40 percent longer; red lead paint lasts as much as 100 percent longer. Tests were on 6 ft. angle lengths.

Table III—Average Mechanical Properties of Commercial High Strength, Low Alloy Steels

(Specimens from hot-rolled plate less than 1/2 in. thick, usually 1/4 in.)

Trade Name	Yield Point, psi	Tensile Strength, psi	Elong. in 8 in. percent	Shear Strength, psi	Charpy Impact, ft-lb Room Temp. avg.	Endurance Limit, psi avg.
Aldecor	50,000[1]	70,000[1]				
Cor-Ten	55,000	75,000	23	3/4 T.S.	40[2]	42,000
Double Strength	50,000[1]	70,000[1]				
Hi-Steel	60,000	74,000	26	3/4 T.S.	50[2]	49,000
Mayari-R	57,600	71,900	28.0			50,000
N-A-X High Tensile	52,000[2]	72,000[2]	27		45.5[3]	45,000
Yoloy HS	55,000	72,000	21	3/4 T.S.	105[4]	48,000
For Comparison:						
SAE 1019 Steel	36,000	64,000			88.5[4]	
Deep Drawing Steel[5]						
(H.R.)	33,000	50,000	27			
(C.R.)	29,000	44,000				

[1] Minimum values—average values not disclosed.
[2] Specimen 1/8 in. thick x 1/2 in. wide x 2 in. gage length (for these two values only).
[3] Keyhole notch.
[4] V notch. Since this is a different method of testing, values cannot be compared with keyhole notch results.
[5] Cold rolled in 1/16 in. thickness and thinner; thicker sheets are hot rolled.

Table IV—Short-Time Tension Test of a Typical Low Alloy Steel at Elevated Temperatures

Temperature of Test, F	Yield Point, psi	Tensile Strength, psi	Elongation in 2 in., percent	Reduction in Area, percent
70	52,000	75,000	35.0	72.5
400	41,500	64,500	32.0	73.0
600	36,500	68,750	30.0	69.0
800	30,000	71,500	34.0	69.4
1,000	26,500	46,500	42.0	65.1
1,200	12,000	21,500	60.5	74.0

Bethlehem Steel Company

100 to 300 percent, compared with mild steels of comparable gage.

To simulate corrosion attack by brine drippings from refrigerator cars, samples of steel and iron were exposed to the atmosphere and sprayed twice a week with a ten percent brine solution. The results showed that low alloy steels are superior to open hearth iron, copper-bearing steel and wrought iron under these conditions.

Higher Strength

Limiting factors governing allowable working stresses in metals of construction are the yield point and the endurance or fatigue limit; these have much greater significance than the tensile strength. As shown in Table III, these new steels have a yield point about 1½ times that of plain carbon steel. The endurance limit is 60 percent higher than that of structural carbon steel (ASTM A-113), giving greater resistance to the vibrations and reversals of stress to which mobile equipment is subjected. Endurance limits determined on rotating beam specimens average 40 to 45,000 psi, or about 60 percent of the tensile strength. This fatigue value is also considerably higher than that of medium-manganese or silicon structural steel.

Because of the excellent tensile properties of these steels, high working stresses are allowable. However, modulus of elasticity is the same as for plain carbon steels. Since the deflection of a member under loading is inversely proportional to its modulus of elasticity, the use of higher allowable unit stresses will be accompanied by a corresponding increase in deflection, unless the section is designed specifically to obtain increased stiffness.

By employing properly designed thin, high strength, low alloy steel sections, dead weight has been reduced in mobile equipment without excessive sagging under load. Railway freight cars, for example, have been made 4,000 to 10,000 lb lighter with these steels as compared with designs utilizing plain carbon steel. Similarly, 30 ft truck trailers have been redesigned with 1,500 to 2,500 lb weight savings.

In designing for reduced weight in structural parts, the following average "tensile-ductility" values for various sheet thicknesses of a typical low alloy steel should be noted:

Thickness in.	Percent Elongation* 2 in.	8 in.	Percent Reduction of Area
1/16	29		
1/8	30		
3/16		25	
1/4		26	60
3/8		26	59
1/2		27	59

* 2 in. gage length on ½ in. wide tensile samples; 8 in. gage length on 1½ in. wide tensile samples. (Information from Inland Steel Co.)

This high ductility accounts for the excellent workability and successful fabrication of the low alloy steels. Workability is far superior to other types of steels which have yield points of approximately the same order.

High strength characteristics of these low alloy steels are retained at moderately elevated temperatures. Table IV shows results of short-time tension tests on ¾ in. round bar stock at elevated temperatures.

Notch Toughness

The low alloy steels obtain their high tensile properties from the alloying elements. This enables carbon to be reduced to values that give improved working, fabricating and impact properties, compared with plain carbon steels of equal yield point—which necessarily have much higher carbon content. High yield point can be achieved in plain carbon steels by increasing carbon content, but at the expense of notch toughness, ductility and weldability.

Notch toughness, or ability of these steels to withstand sudden blows, as indicated by Charpy impact test values at room temperature, is a good deal higher than plain carbon steels of equal yield point. This factor is important where the service life of mobile equipment is likely to be affected by impact.

These excellent impact properties exist both at normal and at low temperatures. This is shown in the following comparison of Charpy impact values of a low alloy steel and a plain

(high) carbon steel of approximately equal tensile strength:

Temperature, F	Charpy V-Notch Impact,* ft-lb	
	SAE 1035	Typical Low Alloy Steel
70	55	130
32	44	130
0	25	128
−25	15	125
−50	10	115
−75	8	95
−100	5	70

* Specimens 0.394 x 0.394 x 2 in. with 45 deg milled notch having 0.01 in. bottom radius, leaving 0.315 in. under notch. (Information from Youngstown Sheet and Tube Co.)

The excellent performance of the low alloy steel in this test is in part explained by the fact that all test specimens were normalized at 1,600 F before machining. The low alloy steel used in this test, for instance, had a room temperature impact value of 105 as-rolled, and a value of 130 after normalizing.

These notched-bar impact values at low temperatures are a good indication of toughness under actual service conditions. The low alloy steels are much better than ordinary steels in notch toughness at low temperatures; they thus exhibit superior resistance to fracture under overland at notches, re-entrant angles, or at other points of restraint.

Heat Treatment

Although these steels are intended for use without further heat treatment, the strength of these steels in the group containing well over 0.60 percent copper can be increased by relatively short precipitation hardening treatments at moderate temperatures. Table V gives tensile and impact results—tested at room and low temperatures—of samples heated for various times at various temperatures. Precipitation hardening also results in increased abrasion resistance. Shown on this page is a precipitation hardened low alloy steel winch head which far outlasted an ordinary carbon steel-head in an abrasion-wear test.

However, abrasion resistance of even the untreated low alloy steels is better than that of plain carbon steels. Service tests in coal and coke chutes proved that a low alloy steel has about 2 or 3 times the abrasion resistance of the carbon steel ordinarily used in this application. The railroad wheel under test illustrates the outstanding abrasion resistance of a low alloy steel containing very little copper.

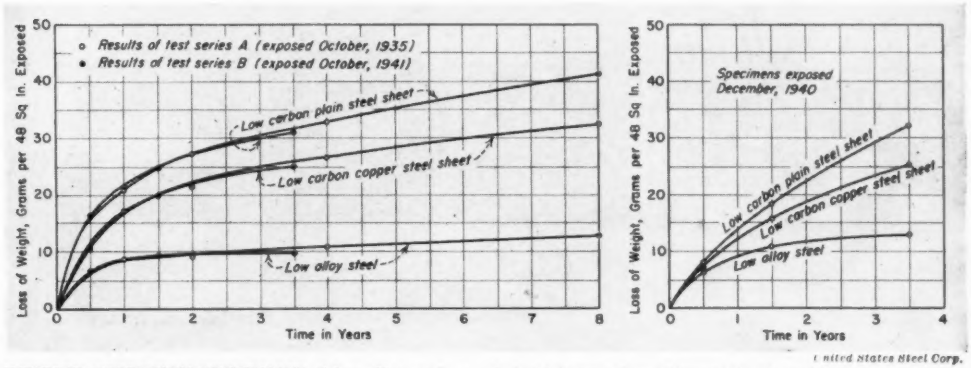
Hardenabilities of these steels are generally so low that plain end

Table V—Properties Resulting from Precipitation Hardening of a Low Alloy Steel

(1/2 in. plate—as rolled condition)

Heat Treatment		Yield Point, psi	Tensile Strength, psi	Percent Elong. in 2 in.	Charpy Impact (Keyhole Specimens) in ft-lb			
Temp., F	Time, hr				75 F	0 F	−25 F	−50 F
950	1	86,060	95,540	32.5	51.0–36.5	26.0–26.0	24.0–24.0	21.0–13.0
950	2	86,260	98,520	32.0	51.0–49.5	22.0–14.5	21.0–15.0	10.0– 6.0
950	4	86,260	98,280	29.5	49.5–50.0	24.0–19.0	22.0– 5.0	21.0–19.0
950	8	82,940	94,990	30.0	46.0–46.0	38.0–33.0	24.0–22.0	18.0– 6.0
950	16	76,220	89,750	29.5	53.0–58.0	59.5–49.5	32.0–48.0	23.0– 5.0
1,000	1	82,980	98,000	30.0	49.0–46.0	29.0–25.0	24.0–22.0	26.5–21.5
1,000	2	85,040	94,360	31.8	50.5–47.0	55.5–31.0	22.0–21.5	21.0–21.0
1,000	4	79,650	91,920	29.2	52.0–49.0	52.0–43.5	33.0–26.0	26.0–17.0
1,000	8	80,180	87,950	30.0	56.0–50.5	60.0–56.0	49.0–32.0	26.5–18.5
1,000	16	72,420	83,420	31.5	59.0–59.0	62.0–59.5	56.0–55.5	32.5–27.0
1,050	1	81,700	95,980	26.2	56.5–55.0	55.0–32.5	24.0–19.0	24.0–21.0
1,050	2	81,010	93,830	28.5	57.0–54.0	56.0–50.0	53.0–14.5	27.5–25.5
1,050	4	78,090	86,560	29.0	56.0–51.0	61.5–57.0	56.0–52.0	57.0–22.5
1,050	8	75,280	82,240	31.0	65.0–56.5	61.5–56.0	58.5–52.5	54.0–53.5
1,050	16	69,570	79,180	35.0	60.0–59.0	64.0–59.0	57.0–50.5	59.0–55.0
1,100	1	83,770	90,800	30.8	50.0–48.0	51.5–36.0	56.0–28.0	43.0–33.0
1,100	2	76,910	85,000	30.0	56.0–48.0	56.5–56.0	50.0–48.0	61.0–29.0
1,100	4	75,320	81,660	31.5	62.0–49.5	60.0–58.0	63.0–54.0	57.5–50.0
1,100	8	72,080	78,100	34.5	58.0–57.5	57.0–57.0	61.0–54.0	59.0–49.5
1,100	16	66,040	77,420	35.5	77.0–55.0	63.0–63.0	60.0–44.0	65.0–39.0

Inland Steel Company


Results of test series A (exposed October, 1935)
Results of test series B (exposed October, 1941)
Low carbon plain steel sheet
Low carbon copper steel sheet
Low alloy steel
Loss of Weight, Grams per 48 Sq. in. Exposed
Time in Years
Specimens exposed December, 1940
Low carbon plain steel sheet
Low carbon copper steel sheet
Low alloy steel
Loss of Weight, Grams per 48 Sq. in. Exposed
Time in Years

United States Steel Corp.

SUPERIOR CORROSION RESISTANCE of low alloy steel, as compared with low carbon copper and plain sheet steels, are shown by these time-corrosion curves of weight loss in (left) an industrial atmosphere (Kearny, N. J.), and in a marine atmosphere (Kure Beach, N. C.). Controlling factors are amounts of sulfur dioxide (industrial) and salt water spray (marine).

Table VI—"L" Bar Hardenability (Rockwell C) of a Typical Low Alloy Steel

(Quenched from 1,630 F)

Distance from Quenched End, in	Cooling Rate at 1,300 F deg F/sec	Percent Carbon 0.07	0.09	0.12	0.17
1/8	665	21	24	30.5	43
1/4	370	20.5	22.5	26.5	42.5
3/8	280	16	16.5	22.5	39
1/2	210	11.5	15	20	35
3/4	115	4	10	9.5	21.5
1	54	−4.5	4.5	2	14
1 1/4	26	−7	−5	−2.5	5.5

Great Lakes Steel Corp.

quench determinations are not delicate enough. Hence, as shown in Table VI, values are given for "L" Bar determination, in which for convenience cooling rates are also given.

Sectional hardnesses of hot rolled, normalized or cold rolled products are uniform, running about 78 B Rockwell. There is no skin since the steel is killed, nor any abrupt changes in chemical composition such as are encountered in rimmed steels.

The low alloy steels do not air-harden appreciably. Consequently, formed sections and welds that can be made in plain carbon steels without heat treatment can also be made in the low alloy steels without heat treatment.

Forming and Fabrication

Accompanying their high yield points, the low alloy steels have exceptionally good workability. In general they can be fabricated by the usual methods employed for carbon steel. They are easily hot flanged, and are more readily punched or sheared than structural silicon steel.

COLD FORMING. Although the low alloy steels are considerably stiffer than structural or mild carbon steels, they can be satisfactorily worked on usual cold forming equipment. However, the inside radius of the bend should not be less than these values:

Thickness of Material, in.	Min. Inside Radius
1/16 and less	1 x thickness
over 1/16 to 1/4, incl.	2 x thickness
over 1/4 to 1/2, incl.	3 x thickness

More difficult forming can be accomplished if the bending is done slowly, and if shear fins are removed. Flat rolled sheets permit more severe cold bending across the direction of rolling than in the opposite direction.

HOT FORMING. When thickness or shape makes cold pressing impractical, hot forming can be used. Because of their relatively low hardenability, the low alloy steels can be hot formed with a minimum possibility of air hardening and with negligible quench effect from cold die surfaces. The heating and air cooling does not cause loss of mechanical properties.

Because of their stiffness, these steels should be hot formed at temperatures about 200 F higher than mild carbon steels. Most satisfactory results are obtained by pressing between 1,500 and 1,600 F (at the dies); it is not considered good practice to hot form below a temperature of 1,200 F. No thermal treatment is required after hot forming.

SHEARING AND PUNCHING. Shearing may require tighter or more secure clamping if a clamp hold-down is used, because the metal tends to pull more than carbon steels. Punching of low alloy steels requires up to 20 percent greater force than for equal thicknesses of ASTM A-7 steel, and up to 40 percent greater force than for ASTM A-113 material.

MACHINING. Sawing, milling and drilling of low alloy steels require about 25 percent more power than for structural carbon steel; use of a coolant is recommended. Tool speed should be about $\frac{1}{3}$ less than for structural carbon steel.

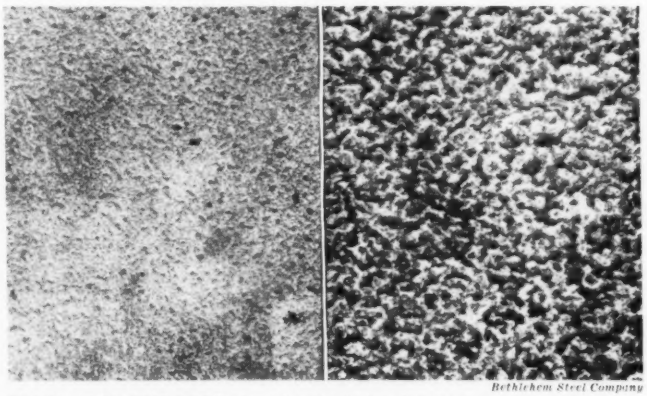
FORGING. Either drawing down or upset forging can be performed on these steels. Soaking at 1,850 F, followed by rapid heating to the forging temperature (about 2,100 F) has been found satisfactory for forging operations.

If, after forging, either normalizing or annealing is considered desirable, a normalizing temperature of 1,650 F followed by cooling in air, or an annealing temperature of 1,550 F followed by furnace cooling, can be used. These procedures can also be used when exceptionally severe cold forming required greater ductility than is obtainable in the as-rolled condition. If it is considered desirable to stress relieve after cold forming or welding, a temperature of approximately 1,150 F should be used. Time at that temperature should be in the order of 1 hr per in. of maximum section thickness.

WELDING. Because they are low in carbon content, low alloy steels do not require special handling in most welding processes. They can be readily welded to each other and to carbon steel; no additional preheating is required for welding low alloy steels than for carbon steel.

Covered electrodes of the AWS E-60 group or their equivalent are recommended for low alloy steels. Welds made with these electrodes have yield points greater than those of the base metal, and in thicknesses up to and including $\frac{3}{4}$ in. have tensile strengths equal to or greater than those of the base metal, even with reinforcements ground off. Percent elongation of such welds is approximately equal to those of weld metal deposited on structural carbon steel.

The use of a mild steel electrode is of considerable practical advantage, since the same electrode can be



Bethlehem Steel Company

TAKEN FROM THE ROOF of a coke wharf after five years exposure to steam and hot-quenched coke fumes, these photographs show the surface condition of low alloy steel sheet, (left) and plain carbon steel sheet (right).

used for welding low alloy steels and structural carbon steels indiscriminately. When low alloy steels are welded to austenitic stainless steel, however, the use of an austenitic stainless steel electrode is recommended.

These steels, in thicknesses of about $\frac{1}{8}$ in. and less, can be spot-welded with about the same conditions of time, pressure and current as are used in the spot-welding of carbon steel. Spot-welds in the low alloy steels maintain ductility; their shear strengths are proportionately greater than those in carbon steel. These steels are readily spot-welded to each other and to spot-weldable carbon steels.

The low alloy steels can be welded by all the well known electric arc and gas welding methods. With the metal-arc process, electrodes conforming to American Welding Society specifications are satisfactory.

Applications

RAILROAD. More than 60 percent of all new lightweight passenger equipment is being built of the low alloy steels. Lightweight cars in passenger trains permit more luxurious fittings and higher speeds without increasing power.

In the freight field, the decrease in dead weight means higher pay load capacity at no extra hauling cost. The improved resistance of low alloy steels to atmospheric corrosion and resistance to abrasion are important factors in open-top cars that handle abrasives.

AUTOMOTIVE. These steels are used for truck and bus construction in several ways:

1. In lightweight construction to increase load-carrying capacity without increasing total gross vehicle weight. A larger body is possible, and relatively thinner sections of steel are specified in the new designs.

2. In the same thicknesses and in the same design as structural carbon steel. Here, cubic capacity and weight are not changed, but strength, durability and safety are increased.

In trucks handling abrasive loads, low alloy steels give much longer life than conventional body steels. By using this steel with new body designs, a large cubic capacity unit can be mounted on a light chassis.

In buses, low alloy steel construction means reduced operating costs, smaller or more economical motors and longer tire wear.

Other automotive products being fabricated of low alloy steels include mufflers, instrument panels, fuel tanks, fenders and bumpers. In former years, a bumper was simple in section and comparatively small; it was made from heat treated SAE 1095 and was essentially a spring. With the advent of more complicated and decorative designs, hot forming became impractical. Cold forming bumpers from low alloy steels has solved this problem and avoided a heating process prior to forming and heating, quenching, tempering and pickling prior to plating. Further economies result, since cold forming permits flat polishing with automatic machinery prior to forming.

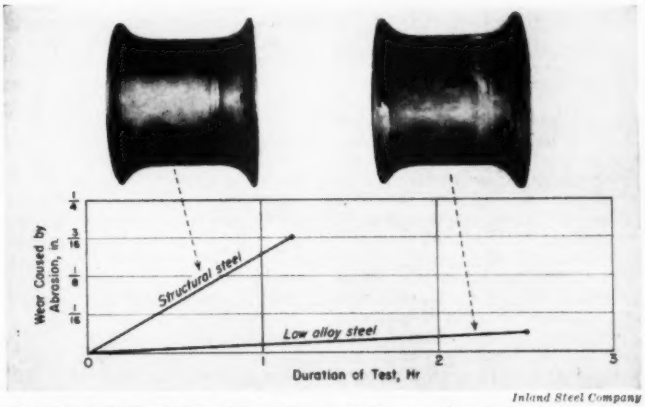
CORROSIVE APPLICATIONS. Where the atmosphere is excessively corrosive, standard power pole line hardware made of structural grade steel and hot dip galvanized does not give ample life. To combat these conditions, galvanized low alloy steel hardware has been developed, which costs only a little more than regular hardware and much less than hardware made of 18-8 stainless steel.

Cylinders containing propane are shipped between widely different locations. Users estimate that savings in transportation costs from the weight reductions obtained by using low alloy steels over a period of 5 years are equal to the original price of the cylinders.

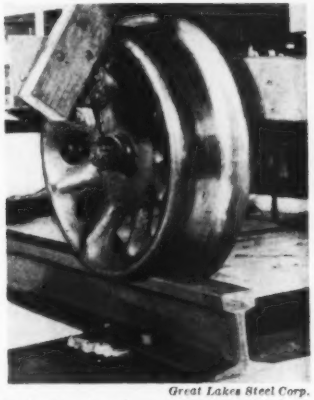
In coke works, where corrosive atmospheres prevail, welded low alloy steel pipe and the supporting framework, fabricated of low alloy steel shapes and angles, resist these conditions much longer than similar carbon steel constructions.

MACHINE PARTS. Low alloy steels are indicated for supporting structures of vibrating machines. An example of such use is in the legs of a washing machine which has two tubs spinning at the same time; while the agitator is washing clothes, the basket of the drying tub is spinning at more than 960 rpm. Plain carbon steels were found inadequate in tensile and vibration-absorbing properties for this application.

EDITOR'S NOTE. PRODUCT ENGINEERING wishes to thank the following companies, for their assistance in supplying information, data and illustrations, on which this article is based: Bethlehem Steel Co., Bethlehem, Pa.; Great Lakes Steel Corp., Detroit, Mich.; Inland Steel Co., East Chicago, Ind.; Republic Steel Corp., Cleveland, Ohio; U. S. Steel Corp., Pittsburgh, Pa.; Youngstown Sheet & Tube Co., Youngstown, Ohio.



Inland Steel Company



Great Lakes Steel Corp.

ABRASION RESISTANCE of low alloy steels is outstanding in both the precipitation hardened and untreated types. Left, winch heads of precipitation hardened low alloy steel greatly outwear winch heads of plain carbon steel. Right, wheel made of a low alloy steel that cannot be precipitation hardened, when rotated against a test rail, nearly cuts through rail head.

LOCATION of minimum oil film thickness, friction torque, and other performance characteristics are measured in this centrifugal bearing test machine. Long flexible shaft is supported at its center by test bearing, loaded centrifugally by adjustable eccentric weights. Edge loading up to 3 degrees and speeds up to 20,000 rpm can be obtained in this specially-developed machine.

Journal Bearing Lubrication

First of three articles, this is a discussion of journal bearing lubrication fundamentals. Types of friction and oil film pressure determine the performance of many machines. Load, speed, viscosity and film thickness relationships affect type of friction.

A. E. ROACH and C. B. GRIFFIN
Research Laboratories Division
General Motors Corporation

PROPER LUBRICATION reduces friction, thereby minimizing wear of rubbing surfaces and power required to drive machines. Basically, there are three types of friction: (1) Dry friction, (2) full-film friction, and (3) partial-film friction. The laws of dry and full-film friction are now quite well understood. Knowledge of partial-film friction is, however, relatively meager.

Dry Friction

True dry friction is rarely encountered, since even carefully wiped machine surfaces remain covered by microscopically thin films of oil, moisture, and other surface contaminants. This is fortunate, because the friction between perfectly dry, clean surfaces is so large that seizure would occur almost instantaneously even with extremely light loads and slow speeds.

In recent years the English investigator F. P. Bowden and his co-workers at Cambridge University have demonstrated that: (1) Even between carefully polished chemically clean surfaces the real area of contact is extremely small in comparison with the apparent area of the surfaces; and (2) although the average pressure may be only a few psi, local pressure between contact points can be great enough to cause them to flow plastically and be crushed down until their cross section is sufficient to support the applied load. These intense pressures, together with the rubbing action, cause welding of the contact points, producing tiny metallic junctions between the surfaces. Since the surfaces have relative movement, tearing, welding, and deformation result. Frictional resistance between the surfaces is caused by adhesion and shearing of the metallic junction and plowing of the softer surface by the irregularities of the harder surface. Thus, progressive disintegration by shearing and plowing rapidly results in appreciable wear and seizure of the surfaces.

Full-Film Friction

Dry friction can be avoided by placing a layer of some easily sheared material, such as oil, between the metallic surfaces. If the surfaces are completely separated by the oil layer, the only

friction resistance to relative movement is that offered by the internal friction or viscosity of the oil itself. Since the coefficient of friction between surfaces completely separated by an oil film are about 0.002 or less, and between dry surfaces about 0.8 or more, there is considerable advantage in having a complete and unbroken film of oil between the surfaces. The problem is how to establish and maintain such a film.

If two surfaces with an oil film between them are pressed together, the oil film will be squeezed out until the surfaces eventually touch each other. If surface contact is to be prevented, a fresh supply of oil must be introduced between the surfaces to replace what is lost through leakage. This can be accomplished in two ways—by hydrostatic or hydrodynamic action.

In hydrostatic lubrication, the oil film is pressurized by an external pump, as shown in Fig. 1. The capacity of the pump is not critical, so long as it is sufficient to replenish oil leaking from between the surfaces. Since pressure of the oil film depends only on the load, increasing the pump capacity simply increases the clearance between the surface and provides a larger channel for the escape of oil. While quite old in principle, this type of lubrication has been little used until recently. The large bearings that support the 200 inch telescope at Mount Palomar are of this type.

In hydrodynamic lubrication, the oil film is pressurized by the internal pumping action of the bearing itself. This internal pumping depends on: (1) Adhesion and viscosity of the oil; (2) geometry of the rubbing surfaces; and (3) relative movement of the rubbing surfaces. Because of adhesion, the oil clings to the bearing and journal surfaces. When the journal rotates in the bearing, adhesive and viscous forces cause portions of the oil to be dragged with it through the clearance space; this space is converging. The convergence results from the load forcing the journal to assume an eccentric position in the bearing, since the radius of the bearing is larger than the radius of the journal.

When oil is dragged through the converging clearance space, it must adjust itself to the smaller volume available. If the viscosity of the oil is sufficently great to prevent appreciable end leakage, its pressure will be increased. Continuous dragging of the oil into the loaded region of the bearing by journal rotation thus provides a high pressure oil film that separates the bearing and journal surfaces, thereby substituting full-film friction for dry friction and preventing abrasion and wear.

Pressure variation throughout the oil film is of utmost importance in bearing lubrication; it determines how and where the lubricant should be introduced into the bearing and provides a basis for grooving bearing surfaces to distribute the oil properly inside the bearing. As shown in Fig. 2, the pressure varies in both the axial and circumferential planes of the bearing. In the axial plane, the pressure varies in a more-or-less parabolic manner. On either side of the pressure peak in the center of the bearing, the pressure diminishes until it reaches atmospheric pressure at the bearing ends, where leakage is occurring. In the circumferential plane, the pressure is a maximum slightly ahead of the point of minimum clearance between journal and bearing, in the direction of journal rotation. Shortly beyond this peak, the clearance becomes divergent and the pressure diminishes. If the oil film does not rupture, negative pressures may exist in the divergent region.

Another essential factor in the lubrication of journal bearings is the development of hydrodynamic pressure in the oil film, which requires a converging clearance space. Load-carrying-ability and frictional characteristics of the bearing depend largely on thickness of the oil film at the point of minimum clearance.

The force exerted by oil-film pressure on a journal bearing supporting a load exactly equals and opposes the force exerted by the load. If the load on the bearing is increased, the oil film pressure automatically increases a corresponding amount. This is accomplished only by increasing the convergence of the clearance space—in other words, by decreasing the thickness of the oil film at the point of minimum clearance. Further increase in load will result in further reduction in oil film thickness, and this process might be continued indefinitely if the bearing and journal surfaces were perfectly smooth.

Actually, a point will eventually be reached where the thickness of the oil film equals the height of the surface roughness. Contact between roughness peaks will then occur. This, load-carrying ability of a bearing depends on oil film thickness at the point of minimum clearance, and it is advantageous to select lubrication conditions that result in the greatest possible thickness at this point.

Film thickness depends not only on

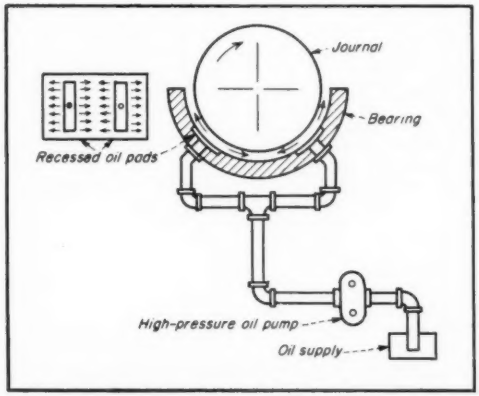


Fig. 1—Hydrostatically lubricated bearing, in which oil film is maintained, by an external high-pressure oil pump, at a pressure that will counteract inward force of bearing load.

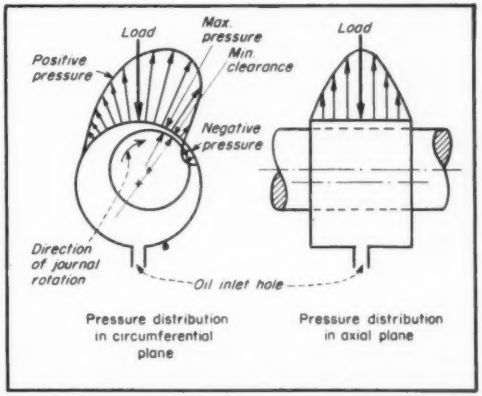
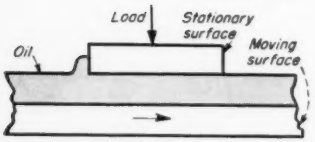
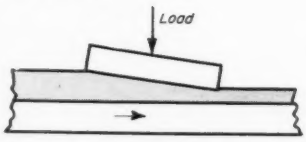


Fig. 2—Oil-film pressure in a journal bearing. Pressure variation throughout oil film in a journal bearing determines how and where lubricant should be introduced into bearing.

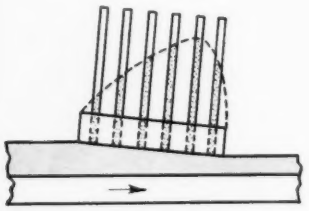
HYDRODYNAMIC THEORY



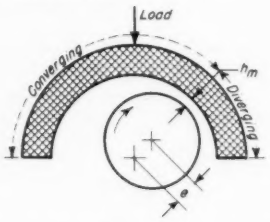
(A) If two parallel surfaces are separated by an oil film and have relative motion, the oil film between them will be eventually squeezed out by the pressure of the load. Because of this squeezing action, parallel surfaces can support only very light loads.



(B) If one of the surfaces is tilted, it will form a converging clearance space into which oil will be dragged by the moving surface. Because of its viscosity, the oil resists the squeezing action of the converging clearance and pressure is built up in the oil film. This pressure pushes the surfaces apart.



(C) If one of the surfaces is equipped with a series of pressure gages, and pressure readings are taken along its length, the pressure of the film will vary in a manner shown in the sketch. The upward force caused by oil film pressure is exactly equal to the downward force of the load: the pressure of the oil film supports the load and separates the bearing surfaces.



(D) If the surfaces are curved in this manner, a partial bearing, such as a railway journal bearing, is obtained. Difference in radii of the surfaces and the eccentricity "e" of the journal center cause the surfaces to form a converging clearance space and build up oil film pressure. Beyond the minimum film thickness h, the clearance diverges, indicating possible negative film pressures.

bearing load but also on journal speed and oil viscosity. If the journal turns so slowly that the rate of oil replenishment is insufficient to replace oil film leakage losses, then film thickness must diminish and reduce volume requirements of the oil film; a balance is thereby struck between rates of flow into and out of the bearing. Similarly, if the viscosity of the oil is so low that the rate of leakage exceeds the rate of oil replenishment, the oil film thickness must again diminish and reduce the cross-section of the channel available for oil leakage out of the bearing.

The relationship between load, speed, viscosity, and film thickness can be simply represented in graphical form, as shown by Fig. 3. Here load p, speed N, and viscosity μ are combined into a single non-dimensional parameter,

$$\left(\frac{r}{c}\right)^2 \mu \frac{N}{p},$$

where r is the journal radius and c is the radial clearance. Film thickness is represented by the non-dimensional eccentricity ratio h_m/c, where h_m is minimum film thickness. The use of these non-dimensional parameters serves to generalize the curve, so that Fig. 3 is applicable to all geometrically similar bearings.

Experiment indicates that when $\mu \frac{N}{p}$ varies, the journal center will migrate along an approximately semicircular path passing through the bearing center and having a diameter equal to the radial clearance of the bearing. Combining this fact with the information in Fig. 3, the location of minimum film thickness can be predicted with respect to the line of load application, as shown in Fig. 4. This information is especially useful in determining the exact location of oil grooves when they must be close to the minimum pressure region.

EFFECT OF OIL-FILM THICKNESS ON FRICTION COEFFICIENT OF THE BEARING. In a bearing with full-film lubrication the friction is entirely viscous friction. Viscosity μ is defined as the ratio of shear stress S to rate of shearing R.

$$\mu = S/R \qquad (1)$$

Since the shear stress S is equal to the ratio of the frictional force F on the bearing to the area A of the bearing, while the rate of shearing R is equal to the ratio of the surface speed U to the film thickness h (when the viscosity distribution is linear), then equation (1) can be rewritten

$$\mu = F h / A U \qquad (2)$$

Noting that $A = \pi D L$, where D is the diameter of the journal and L is the length of the bearing, and that $U = \pi D N$, where N is the journal speed in rpm, the frictional force F acting on the bearing can be obtained in the special case where journal and bearing centers are coincident.

$$F = \frac{\pi^2 \mu N D^2 L}{h} \qquad (3)$$

The friction coefficient f is defined as the ratio of the frictional force F to the normal load W ($= pA$, where p is the unit pressure on the bearing),

$$f = F/pA = F/p \pi D L \qquad (4)$$

Substituting in Eq (4) expression for F previously determined,

$$f = \frac{\pi \mu N D}{p h} \qquad (5)$$

Equation (5) shows that the friction coefficient varies inversely as the unit pressure p and the film thickness h. If film thickness were neglected (or assumed to be constant), the friction coefficient would be a straight line (called Petroff's line) when plotted against $(r/c)^2 \mu N/p$, as shown in Fig. 5. However, since friction coefficient increases with decrease in film thickness, the actual curve lies slightly above Petroff's line. For very small values of $(r/c)^2 \mu N/p$, the film thickness becomes so small that partial-film conditions are encountered, and the friction coefficient increases abruptly. By comparing Fig. 3 and Fig. 5, the relation between friction coefficient and minimum film thickness can be further studied.

Partial-Film Friction

When the quantity of oil supplied to a bearing is sufficient to replace all the oil that is lost through leakage, the

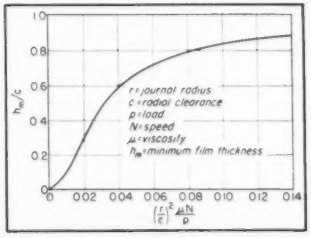


Fig. 3—Relationship between load, speed, viscosity and film thickness in hydrodynamic oil films on journal bearings, expressed in nondimensional parameters.

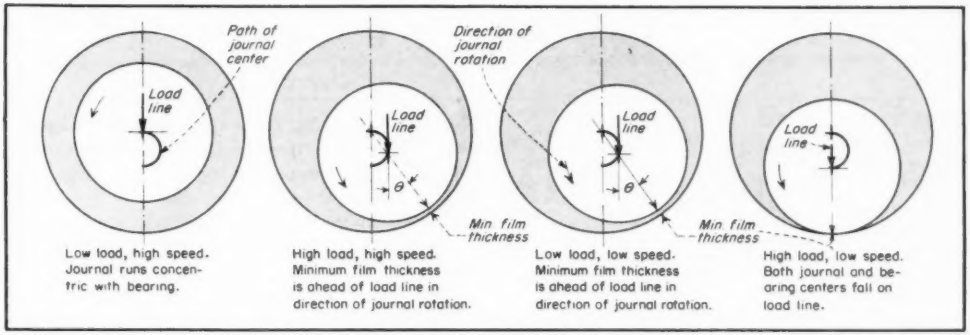

Path of journal center
Load line
Direction of journal rotation
Load line
θ
Min. film thickness
Load line
θ
Load line
Min. film thickness
Load line
Low load, high speed. Journal runs concentric with bearing.
High load, high speed. Minimum film thickness is ahead of load line in direction of journal rotation.
Low load, low speed. Minimum film thickness is ahead of load line in direction of journal rotation.
High load, low speed. Both journal and bearing centers fall on load line.

Fig. 4—Journal running positions for various conditions of load and speed (clearance greatly exaggerated). Based on information in Fig. 3, this shows location of minimum film thickness with respect to line of load application in geometrically similar bearings.

oil film will extend completely around the bearing. If the oil supplied is slightly less than that required to replace leakage losses, the oil film will break in the divergent region; thus the arc covered by the film will be less than 360 degrees. Hydrodynamic lubrication can still be obtained, but the bearing will function as a partial rather than a complete journal bearing. Further reduction in the quantity of oil supplied will further reduce the arc covered by the film until it can no longer support the load imposed on it. The bearing may still run on a very thin film of oil, but its friction characteristics will no longer be determined solely by the viscosity of the oil. Full-film friction thus ceases, with the friction coefficient increased to 0.1 or more.

The ability of very thin oil films to support loaded bearing surfaces in the absence of hydrodynamic action has not as yet been explained in a thoroughly satisfying fashion. The most recent investigations of this phenomenon indicate that certain components of the lubricant react chemically with the bearing metal and form metallic "soaps" on the bearing surface. These soaps reduce the amount of metallic contact by resisting penetration by the roughness peaks of the rubbing surfaces. The effect is only relative, however; some peaks break through the soap film and form pressure-welded junctions. Frictional resistance of the surfaces to relative movement is a combination of the resistance to shearing of the metallic junctions and of the metallic soap. Since this is a mixed condition, involving both dry friction and film friction, it is referred to as partial-film friction.

Operation of a bearing under partial-film conditions requires a lubricant and bearing metal that are mutually reactive in the formation of metallic soaps. Animal and vegetable fats are much more active than mineral oils in this respect, but unfortunately their lack of chemical stability makes them undesirable lubricants for most purposes. Among the metals, nickel and chromium are quite unreactive, while lead, tin, copper and their alloys are comparatively reactive.

Since partial-film friction is a mitigated case of dry friction, the dry friction characteristics of the rubbing surfaces must also be considered. One of the rubbing surfaces must be a material that has low shear strength, low melting point, and high heat conductivity; these properties tend to minimize the ill effects of high pressure at contact points. Babbitt metals possess these properties to a marked degree. Bearing bronzes, copper-lead alloys, and silver alloys are somewhat inferior to babbitt in frictional properties but are superior in rigidity and fatigue strength, under heavy loads.

Although the objective of lubrication is always to obtain a full-film of oil between the rubbing surfaces, in actual operation of any bearing partial-film friction will be encountered at some time. Even in bearings designed for full-film lubrication, provision must be made for partial-film operation—suitable bearing metals must be used—since the bearing passes through a partial-film condition in starting and stopping.

Two common causes of partial-film friction in bearings are: (1) Faulty bearing geometry — improper oil grooves or sharp edges at parting lines of split bearings, and (2) insufficient oil supply. Since these two conditions are so frequently encountered and are so easy to correct, they shall be considered in great detail in future articles of this series.

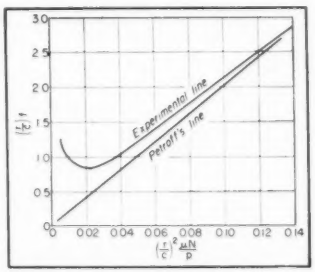


Fig. 5—Friction coefficient is a straight line relationship (Petroff's Line) if film thickness is neglected. Actual curve shows that friction coefficient increases with decrease in film thickness.

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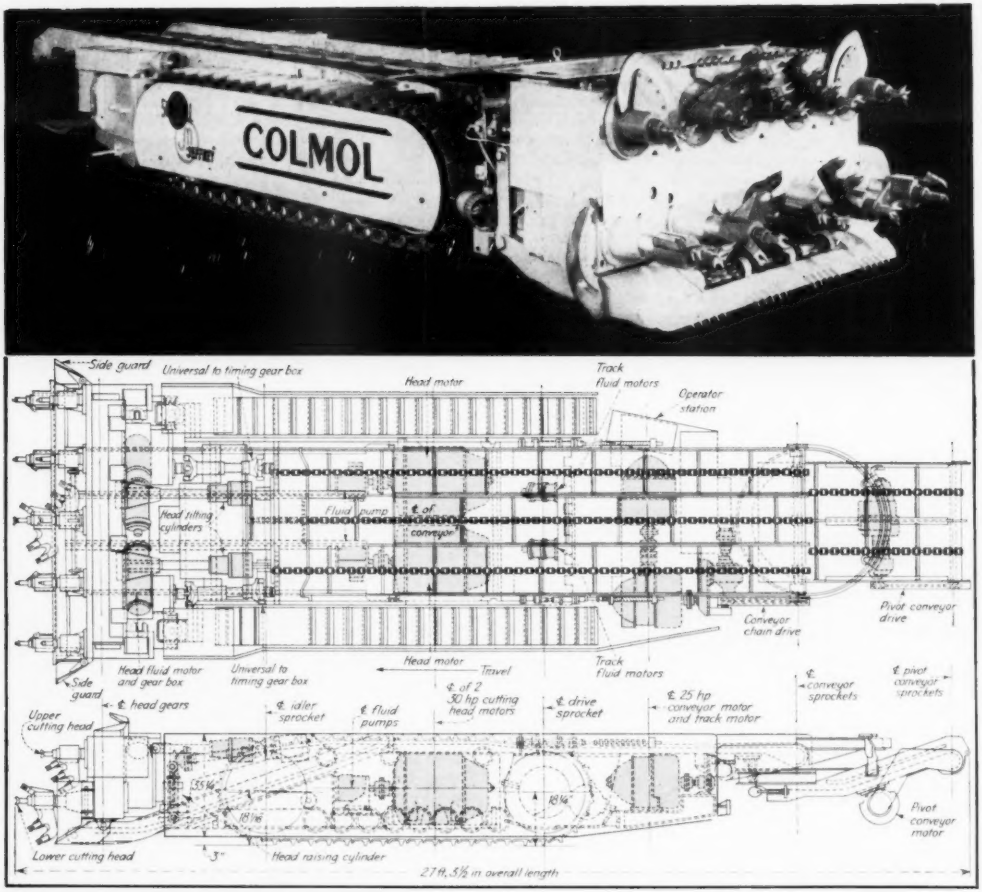
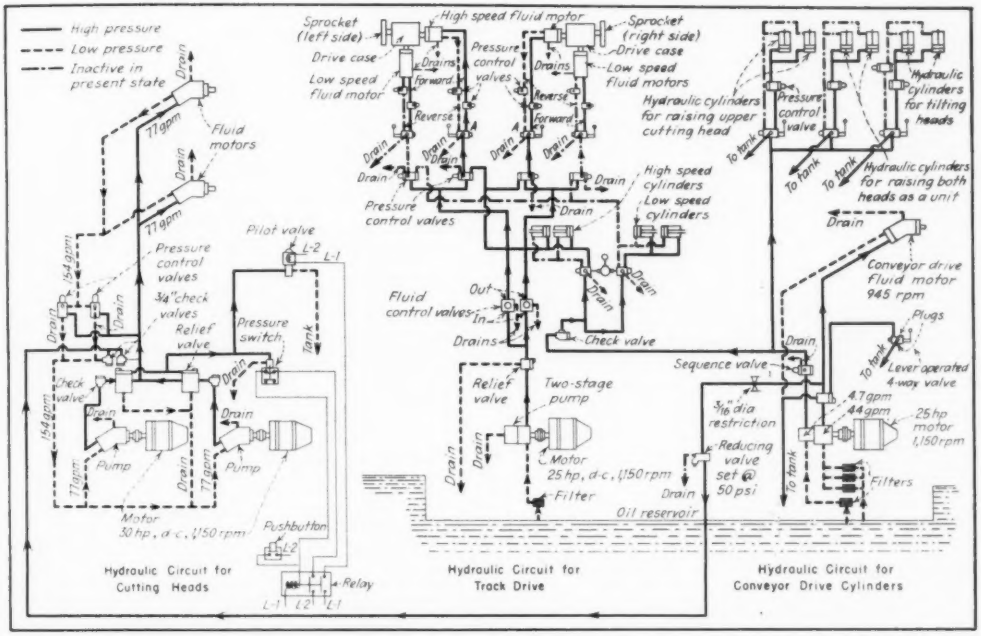
EDITORS NOTE: The second article in this series will be presented in the November issue of PRODUCT ENGINEERING.

Automatic Coal Miner Features Hydraulic Drives

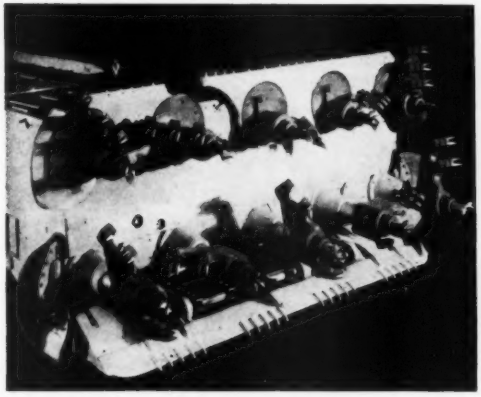
Space was the limiting factor in the design of the Colmol, the automatic miner developed by the Sunnyhill Coal Co. of Pittsburgh. It was found impossible to get the drive motors close to the driven elements without exceeding space limitations. The choice of hydraulic drives facilitated the required remote positioning without the use of complex mechanical couplings and gearing. The Doug Turner Eng. & Sales Company of Salem, Ohio cooperated in the design of the Colmol, which is being manufactured by the Jeffrey Mfg. Company of Columbus, Ohio.



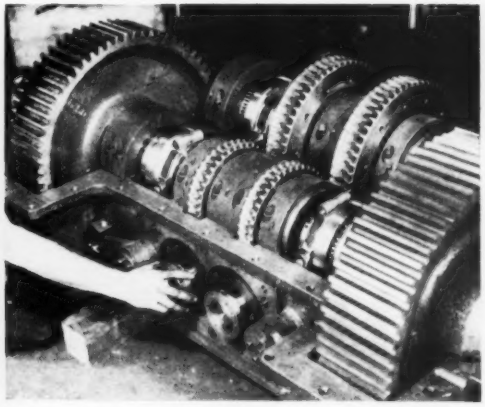
TWENTY-FOUR TON MACHINE can cut and load as much as 5 tons of coal per min. One man operates it. Shaded portions of above drawing indicate motors and fluid drives. Cutting tools are mounted on two separate castings—the upper and lower cutting heads. Hydraulic cylinders are used to raise or tilt the cutting heads. Since the cutters overlap and are driven by fluid motors, they must be timed to prevent interference with one another. This is done by extending the transmission drive shafts back through universals to a timing gear box.



THERE ARE THREE main hydraulic circuits, as shown. Two 30 hp explosion-proof motors drive the pumps which supply the hydraulic motors for the cutting heads. The circuit for the track drive is a constant-delivery, constant-speed system. Separate valves permit each track to be operated at high or low speed in either forward or reverse. The position of the 4-way lever-operated valves determine the direction of track movement. Although the d.c. motors are rated at 30 hp each for the head, they sometimes operate at 200 percent of rating.

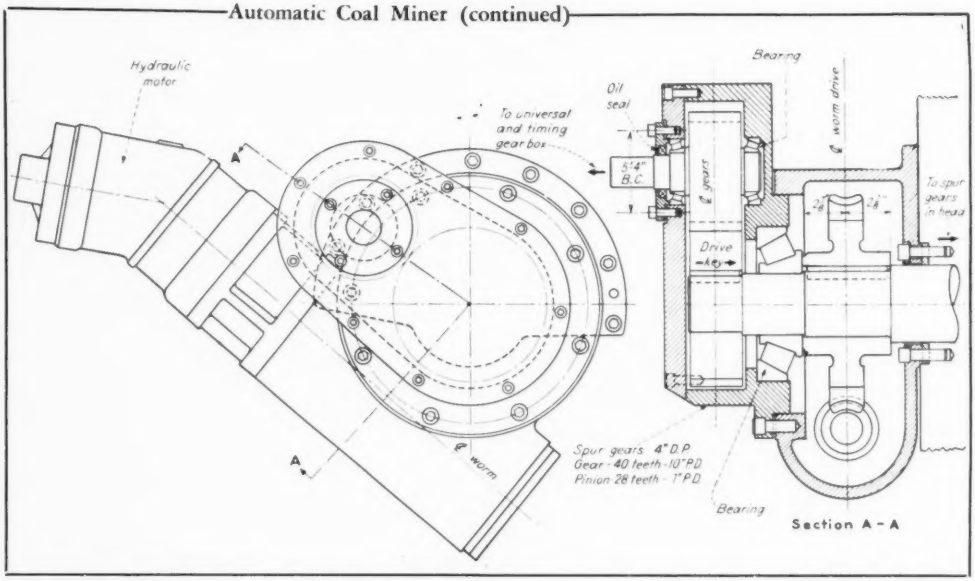


CUTTERS to the left of center operate in a counter-clockwise direction, those to the right of center in a clockwise direction. This action sweeps the coal toward the center where it may be picked up by the conveyor as the machine moves forward. Tools are of carbide or high alloy steel.

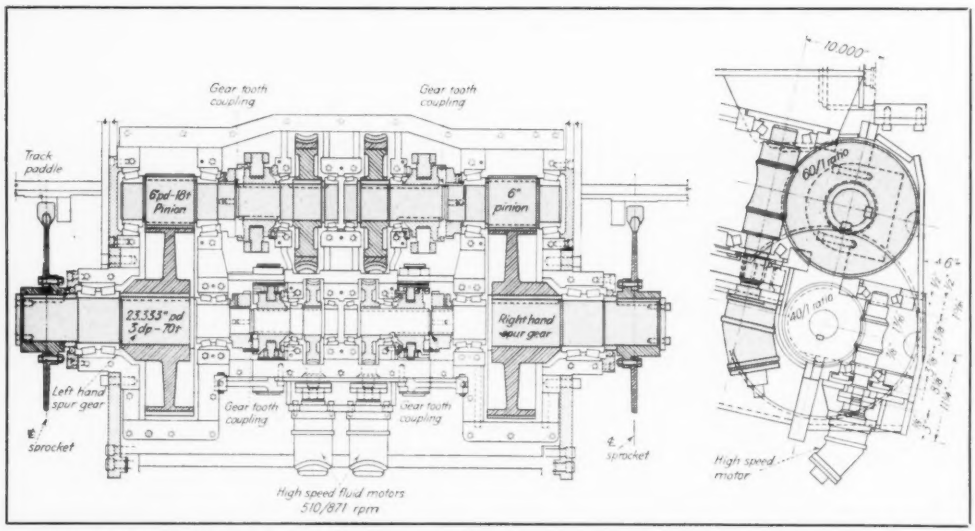


CONE-DRIVE GEARING is used in track drive transmission to save space. The distance from the center of the worm to the center of the gear is considerably smaller than the same distance on conventional worm gearing for transmitting equal power. (*Continued on next page*)

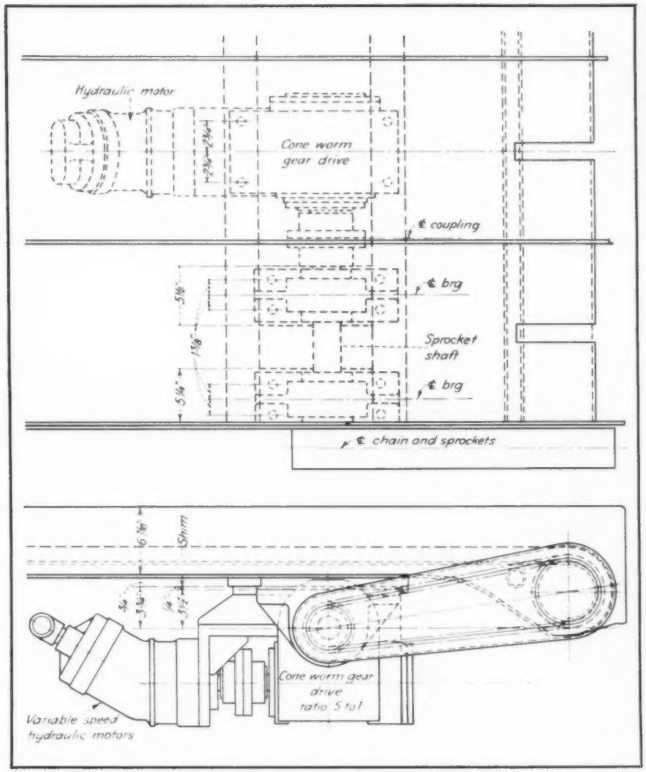
Automatic Coal Miner (continued)



TWO FLUID MOTORS drive the cutting tools. One of the motors operates the cutters in the upper head, while the other drives the cutters in the lower head. Each motor is mounted in line with the worm of a Cone-Drive transmission. One end of the cone gear shaft connects to the spur gear train that drives the cutters. The other end of the shaft leads to the timing gear box via a spur gear train and universal joint. The timing gear box conveys no driving force. Its only purpose is to keep the cutting heads in perfect synchronism.

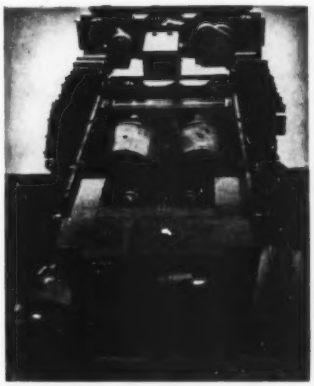


TWO LOW SPEED MOTORS (one for each track) work in conjunction with the low speed gearing. The power flow at low speed is indicated by the shaded areas above. For high speed movements, the high speed motors and low ratio gearing drive the tracks. Selection of high or low range gearing is accomplished by means of four gear tooth couplings. Hydraulic cylinders actuate these couplings. Low speed movement of the machine is variable from 0 to 3 fpm; high speed, from 3 to 13 fpm. Valves controlling fluid flow to drive motors determine speeds.

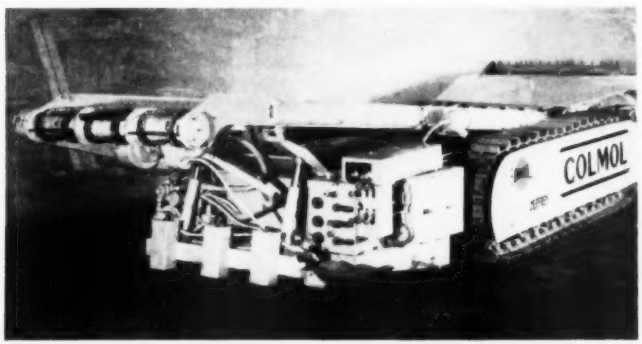


CONVEYOR DRIVE ARRANGEMENT. The hydraulic motor, which has a top rated speed of 945 rpm, drives the sprocket shaft through a cone worm gear drive. Two bearings support the sprocket shaft. The reason that the fluid motor is not mounted closer to the sprocket is that one of the 30 hp motors that operate the pumps for the cutters is mounted beneath the bearings.

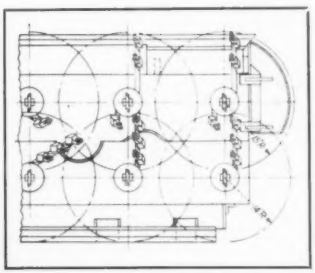
INTERLOCKING arrangement of cutter drive motors conserves space. An advantage of hydraulic drive is that machine operates with little vibration —an important feature for mine work.



FOUR electric motors that operate the hydraulic pumps are visible above. The power supply for these motors is through a cable which drags along behind the machine back to the electric supply panelboard.



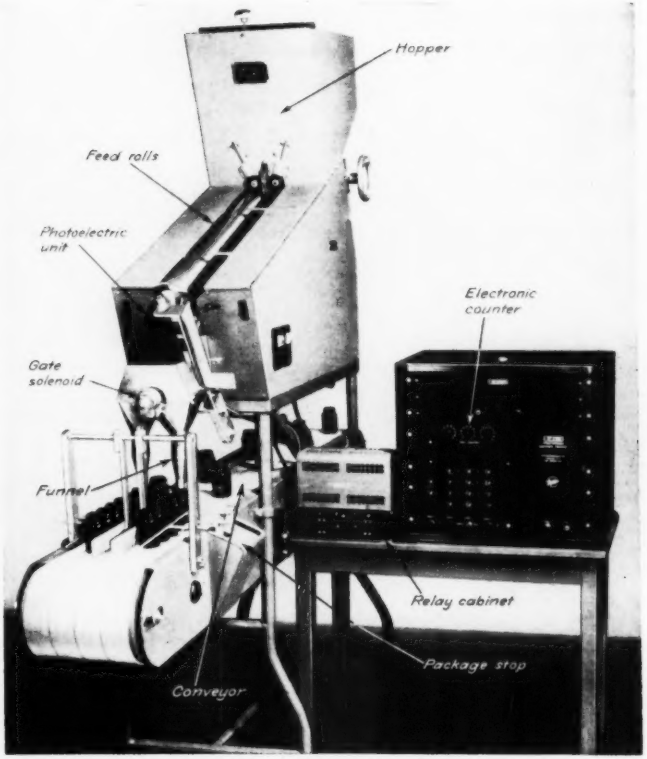
OPERATOR'S SEAT is at the rear of the machine. It is placed very close to the ground because of limited clearance in mines. Controls are mounted in front of operator. The machine is capable of cutting up to 10 tons of coal per minute. However, the present methods of disposing of the cut coal make this rate impractical.



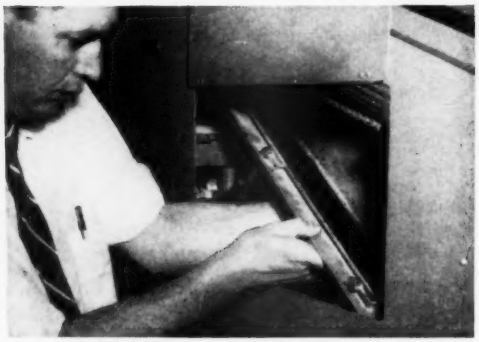
OVERLAPPING of the chipping heads is chosen so that they will always cut clearance for the machine. Cutters also function as paddle conveyors which sweep the floor of the mine, carrying loose coal up to the conveyor. The delivery end of the conveyor can be raised or lowered to accommodate cars of various heights.

Positive Feed Permits High-Speed Packaging of Small Parts

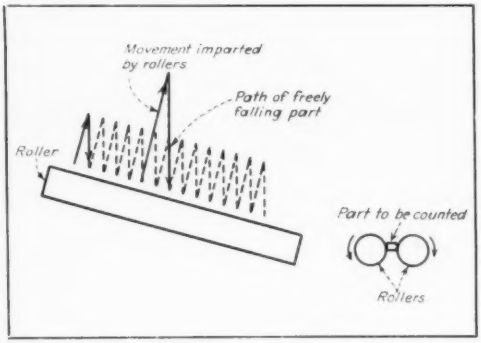
The "Count-O-Matic" machine automatically counts and packages as many as 330,000 small parts per hr. Among the products that can be handled by the machine are steel balls, screws, candies and pills. The accuracy and speed of this machine depends on its ability to separate each small part from the others, then deliver it to the counting device under controlled feed conditions. Two inclined rollers are the principal components of the feed mechanism. The rotation of these rollers actually forces each individual part along a path between the roller axes. The U. E. Engineering Company of New York City makes this machine.



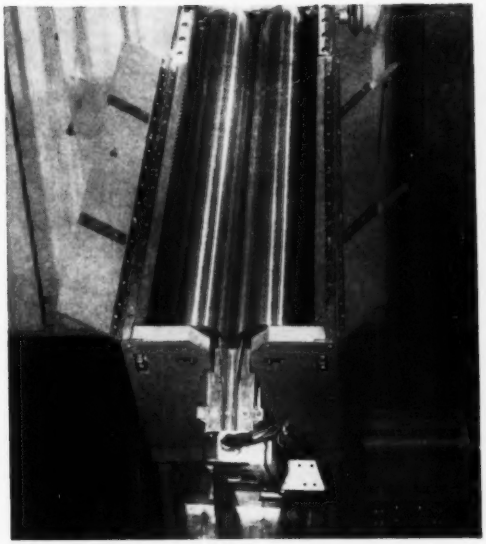
FOR PACKAGING, parts are poured into the hopper at top of machine. The parts move along the rollers, drop past the photoelectric unit and into the bottles or boxes. When the established quantity of parts have passed into a bottle, a solenoid operated gate deflects flow to bottle in adjacent line.



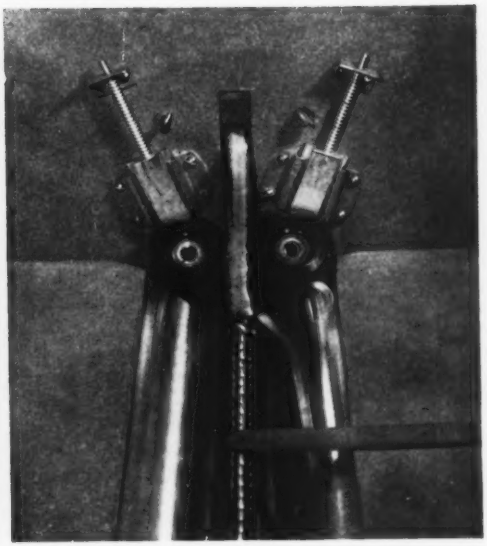
BRUSHES MOUNTED beneath rollers keep their surfaces free of grit. Roller speed—and hence the speed of the parts or objects—is regulated by means of Reeves-type pulleys. The location of the rollers axes is variable. The rollers can be moved closer together or farther apart to accommodate objects of various sizes.



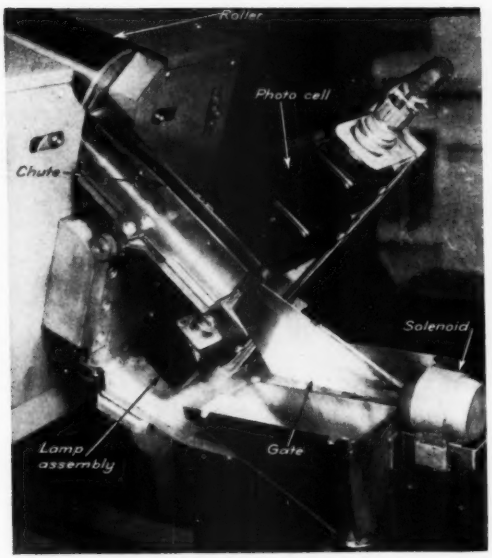
COMBINATION of tangential and gravitation forces provide forced movement of small objects. The objects do not slide—although the rollers are inclined. The parts will move only while the rollers are in operation. This sketch shows—in greatly enlarged detail—the paths described by movement of the objects.



TWO PARALLEL cylindrical rollers form the bottom of the hopper and run the length of the machine. These are cut from tubular stock, then fitted with end plugs and tapered roller bearings. When the machine is in operation, rollers revolve so that their adjacent sides move upward.



ROTATING BRUSH meters the flow of parts from the hopper. This brush is driven from the two feed rollers by means of two spring-loaded idler wheels. Direction of rotation is such that brush tends to oppose movement of parts. Brush breaks up any jamming of parts around orifice.



DOUBLE-ACTING rotary solenoid operates the gate when the flow is to be directed to the alternate funnel. Thus, flow of parts can be continuous with a container being filled through one funnel while an empty container is being moved into position under the second funnel.

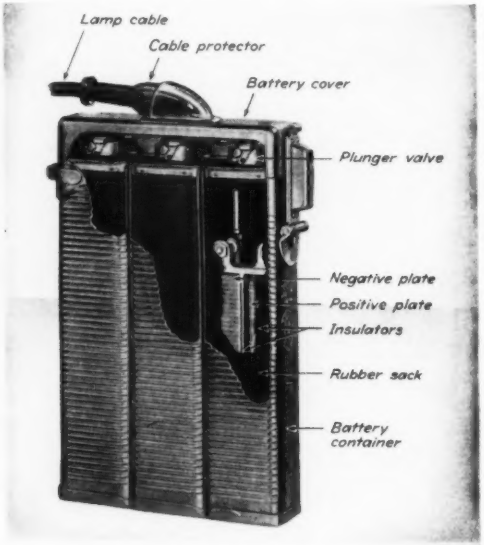
AS IT LEAVES the delivery chute, each part breaks the light beam that is focused on the photoelectric cell. The resulting signals from the cell are recorded by the electronic counter. As they drop from the rollers, parts speed up. This assures proper separation for accurate counting.

Twinned Cells Make Compact Battery Design

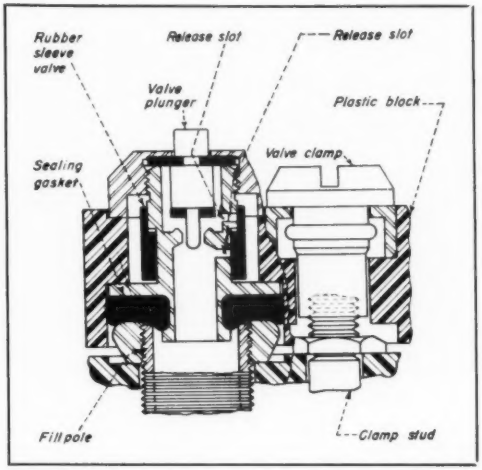
Engineers of Thomas A. Edison, Inc. in West Orange, N. J. have designed a new mine lamp with 25 percent more light output. However, the weight and size of the outfit was not increased proportionately. A nylon case and a new type of cell construction contribute to the compactness of the unit. The new lamp is provided with a focusing adjustment. Mechanized mining brought about the need for this feature. Miners working with machines stand farther back from the work face and, hence, require a stronger spot to illuminate the area. The U. S. Bureau of Mines has approved the new lamp.

LIGHT OUTPUT of new lamp is 25 percent greater than former model. This has been accomplished by stepping up the potential of the battery to 4.85 volts. It was 3.70 volts before. This permits use of a bulb of higher voltage and therefore of higher efficiency. Despite increase in light output, the redesigned unit is only slightly larger. The use of "twinned" cell construction and a molded nylon case enabled Edison engineers to produce a compact unit. A stainless steel hood covers the cable connections, charging terminals and filler valves. A magnetic lock prevents tampering.

USE OF FOUR CELLS in battery makes twinned cell construction possible. In twinning, the steel cases of two cells are welded together with a common partition. Since the internal connections are such that the two cases are of opposite polarity, cell voltages are additive. Only one terminal need be brought out from each cell.



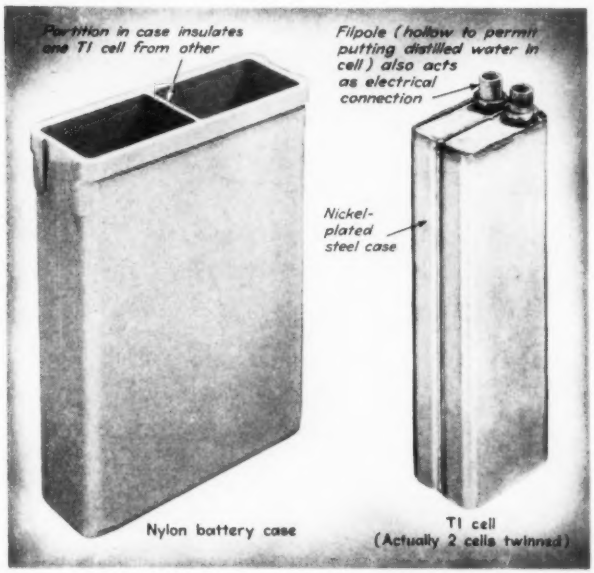
THREE INDIVIDUAL CELLS made up the former battery. The insulation required around each cell was a space-taking factor which has been eliminated in the new model. Two terminals were brought out from each cell. In the new battery the only insulation required is that between the pairs of twinned cells.



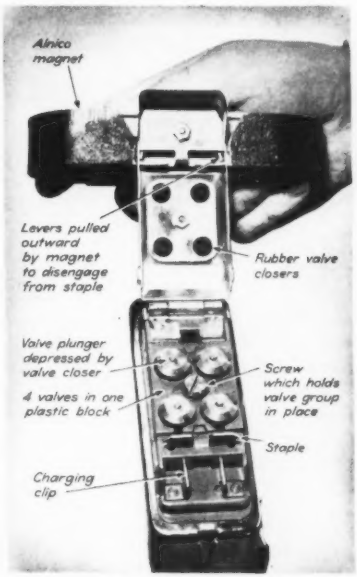
VALVE COVERS the filler tube which is also the electrical terminal of each cell. This valve is so designed as to prevent spillage of electrolyte regardless of the working position assumed by the miner. In practice, the battery is charged every night. The battery capacity is more than ample to operate lamp for full work day.

Bulb holder arm holds bulb in electrical contact. Reacts to cool filament rapidly if glass bulb is broken
Double filament bulb
Safety switch which breaks electrical circuit if bulb is broken
Switch drum which is rotated to light either of the two filaments in bulb
Bulb holder and switch blade assembly
Yoke containing safety mechanism can be moved axially and transversely to position bulb filament for focusing in reflector
Wrench operated lock to secure bezel to housing

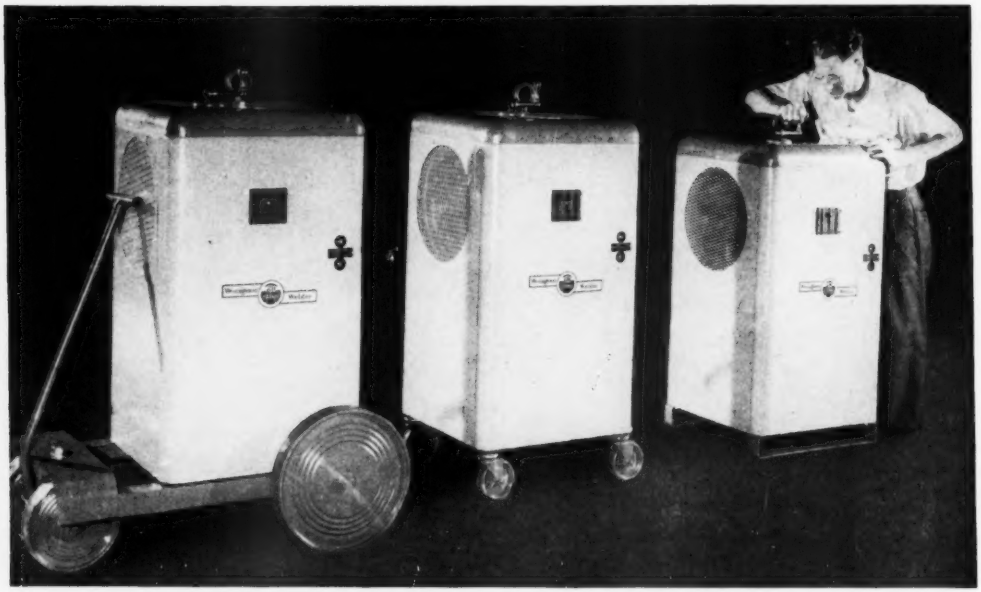
HEADPIECE is composed of plastic case and an aluminum bezel. The safety mechanism is floated on an aluminum yoke which permits the bulb to be moved in and out along its axis or transversely. This feature is used for focusing the light spot. Should the bulb break, spring-loaded bulb holder and switch blade will snap up, breaking circuit.


Partition in case insulates one T1 cell from other
Filpole (hollow to permit putting distilled water in cell) also acts as electrical connection
Nickel-plated steel case
Nylon battery case
T1 cell (Actually 2 cells twinned)

NYLON CASE is molded in one piece and acts as the insulation between the pair of twinned steel cells. A set of these twinned cells is shown on the right. In the preceding model, each cell was separately insulated. Thus, the selection of a nylon case helped greatly to design a compact and light weight unit.


Alnico magnet
Levers pulled outward by magnet to disengage from staple
Rubber valve closers
Valve plunger depressed by valve closer
Screw which holds valve group in place
4 valves in one plastic block
Staple
Charging clip

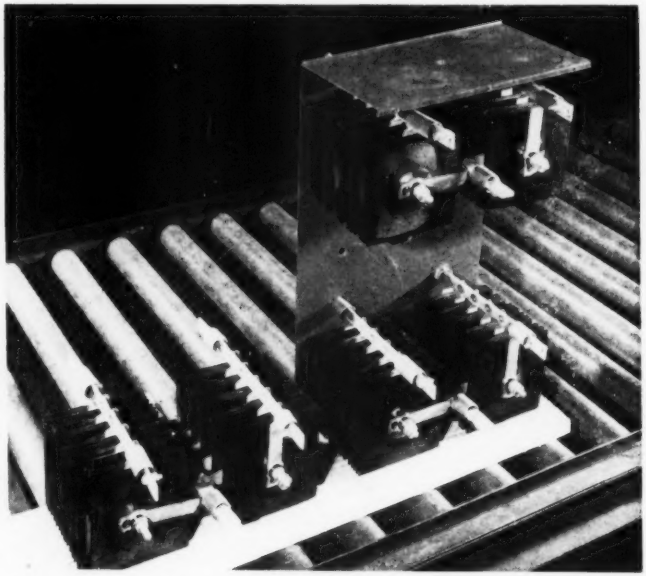
MAGNETIC LOCK secures the stainless-steel cover of the nylon battery case. This design, originated by Edison engineers, discourages miners from opening the hood and exposing battery terminals. This is a safety feature required by Bureau of Mines.



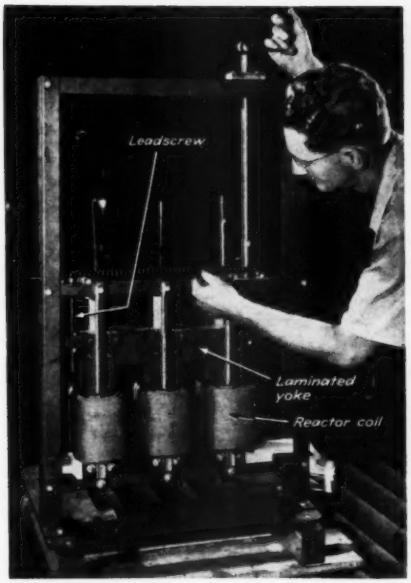
NEW WELDER is as stable and transportable as the conventional horizontal-type motor-generator welder. The designers accomplished this by mounting heavy components near the bottom of the unit. Thus, its center of gravity is low. The welder is equipped with either wheels, casters or skids depending on the degree of portability required.

D-C Welder Uses Dry Rectifiers

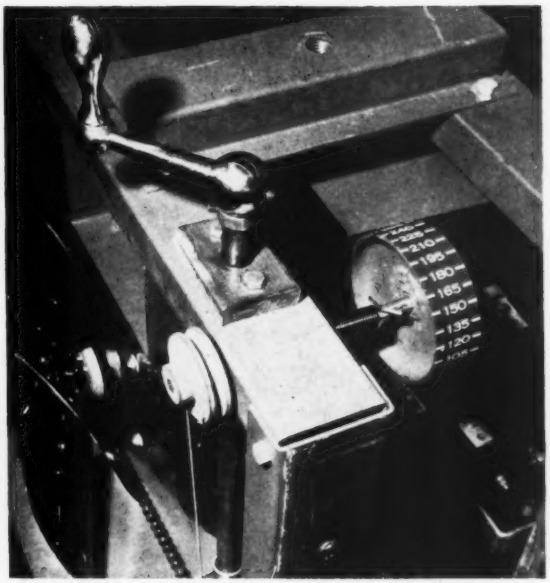
The Westinghouse Electric Corporation has developed a new d-c welder that uses no large rotating elements. In place of the conventional motor-generator set, selenium rectifiers produce the d-c welding current. The elimination of rotating machines keeps wear to a minimum. Since there are no friction and windage losses, the new unit has a higher efficiency. At full load, the efficiency is 66 percent compared with 54 for a conventional welder. The new unit weighs less than half as much as a motor-generator welder of equivalent rating and takes less floor space.



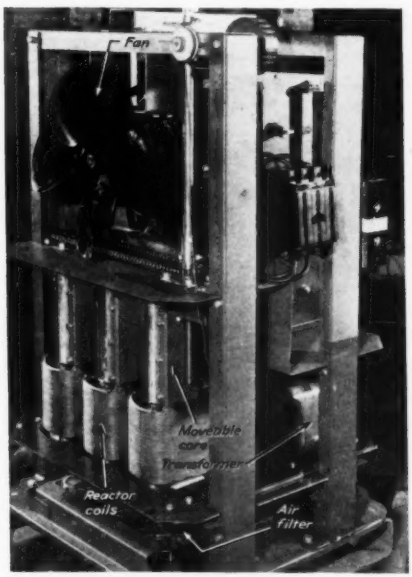
SIX STACKS of selenium plates effect full wave rectification of the three phase alternating current. Each of the six stacks is identical for simplicity of assembly and replacement. For the 300 amp welder, these rectifiers deliver currents ranging from 30 to 400 amp, depending on reactor setting.



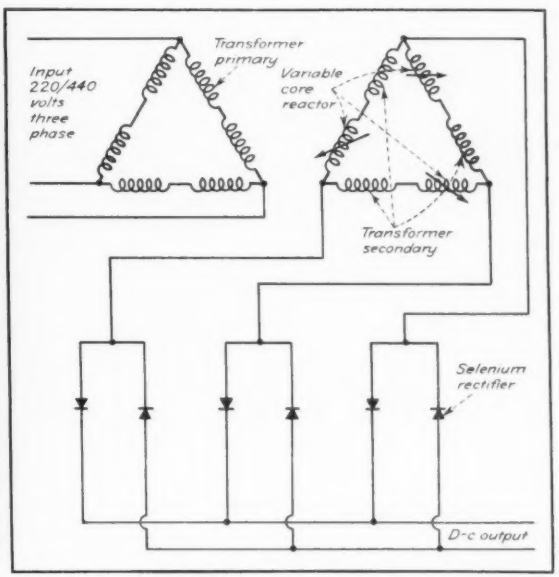
WHEN HANDLE IS TURNED, the chain-connected lead screws move laminated yoke up or down, varying inductance of the reactor coils.



CONTROL HANDLE for adjustable reactor is at top of welder. Movement of this handle regulates the welding current. The indicator drum shows handle setting in amperes.



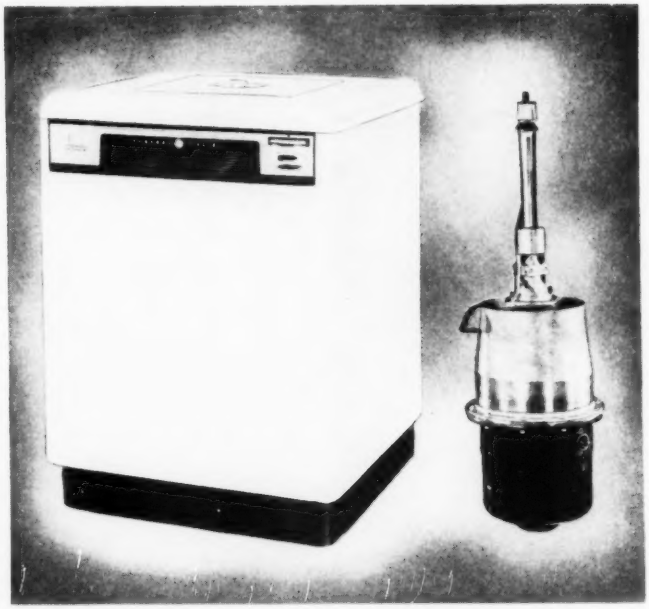
COOLING FAN is the only moving part. Thus, new welder is extremely silent when compared with the motor-generator type. Also, the no-load losses are over 80 percent less.



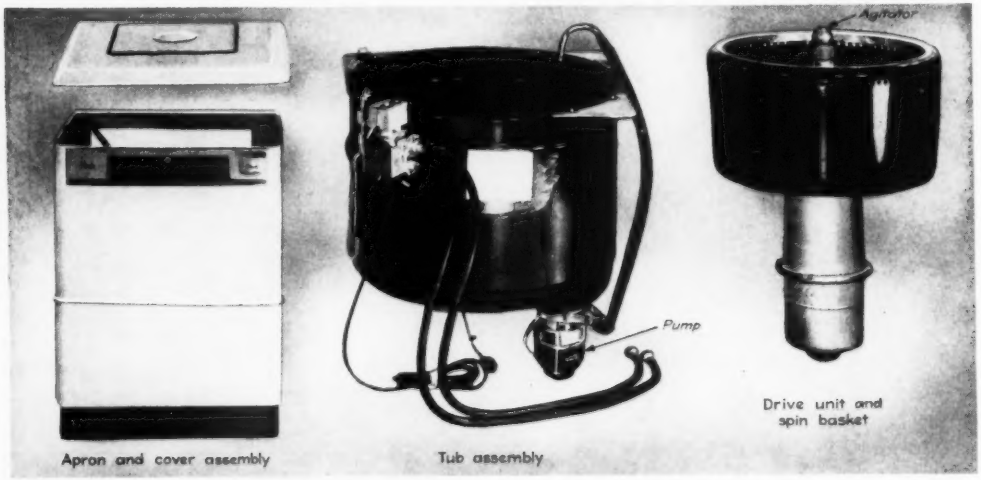
REACTOR COILS are in the secondary circuit of the transformer. These coils control the output current but do not affect open-circuit voltage of 70 volts. In a conventional machine, current is increased by raising voltage. Open circuit voltage may be as high as 115 volts.

Sealed Drive Unit Powers Automatic Washer

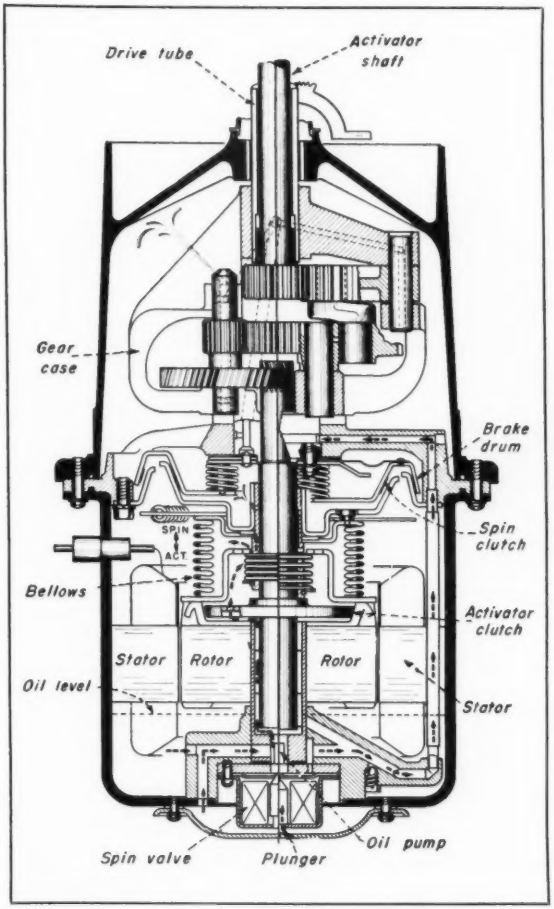
The General Electric Company is in production on a new version of their automatic washer. While performance and capacity of the new machine equals that of the previously introduced Deluxe model, its price is $70 less. Simplified control devices and the use of powdered metal pressings for many parts contribute to the reduced cost. Feature of the G.E. washer is a sealed unit which powers both agitator action and high speed spin. A new mounting device holds unit rigid during agitation but allows it to tip freely during spin.



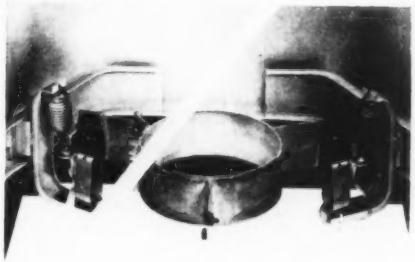
WASHER CAPACITY is 9 lb of dry clothes. Although machine uses high speed spin for water extraction, it does not require bolting down. All gears used in drive mechanism are of copper-impregnated sintered iron construction for economy reasons. The largest of these pressed gears has about 3¾ in. diameter. Sealed power unit contains drive motor, gear reduction for agitator action and a hydraulically operated clutch for the high speed spin. Connection to all external controls is through a 4 prong connector on the motor shell.



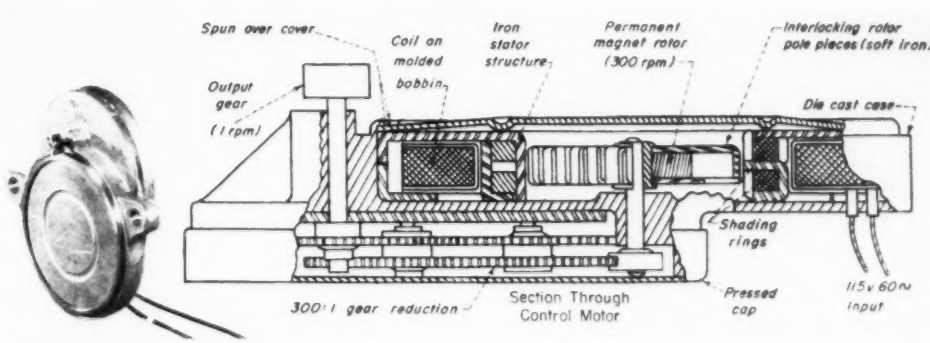
THREE MAJOR COMPONENTS make up the washer. The tub acts as chassis for the inlet water valve system; the control and starting relay; water level control; electrical harness and drain pump. This sub-unit construction facilitates factory assembly and field service. In a completed washer, unit can be changed in about 8 minutes.



SINCE OIL PRESSURE is available for lubrication and cooling, a bellows type clutch shifter is used for changing from agitation to spin. This has the advantage of positive disengagement when the motor is stopped. Spin is initiated by energizing the solenoid valve at the bottom. With the plunger closed, oil is forced up the motor shaft into the bellows which expands and engages the clutch cones. At the same time, the brake (outer cones) is lifted off allowing the gear case to accelerate freely. The drive tube carries the washing basket and is connected to the rotating clutch through the gear case. In the sketch, at the left, the spin conditions are shown on the left and agitation conditions on the right.



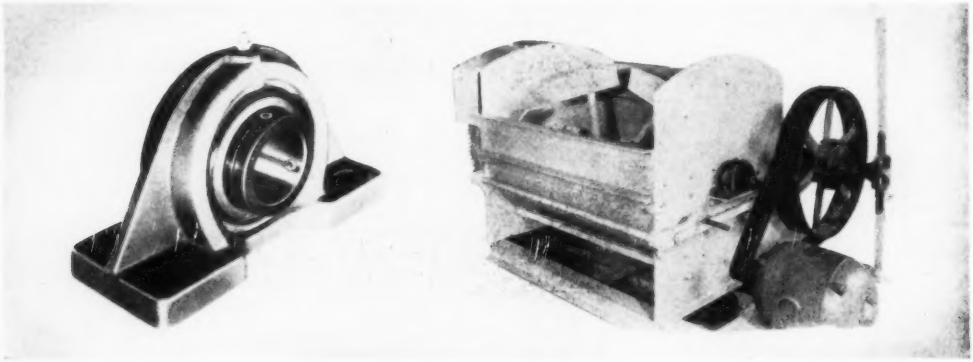
CLAMP BAND has 3 radial arms supported at the ends by tension springs. When fully loaded, extension of these springs allows the arms to rest on 3 rubber pads. This provides rigidity for the wash cycle. At the start of spin, the loss of water from the basket raises the arms off the pads and allows basket to gyrate. To limit the maximum amplitude during unbalance, sliding friction was added to the elastic system. This is in the form of pads of molded brake lining rubbing on the sides of the radial arms.



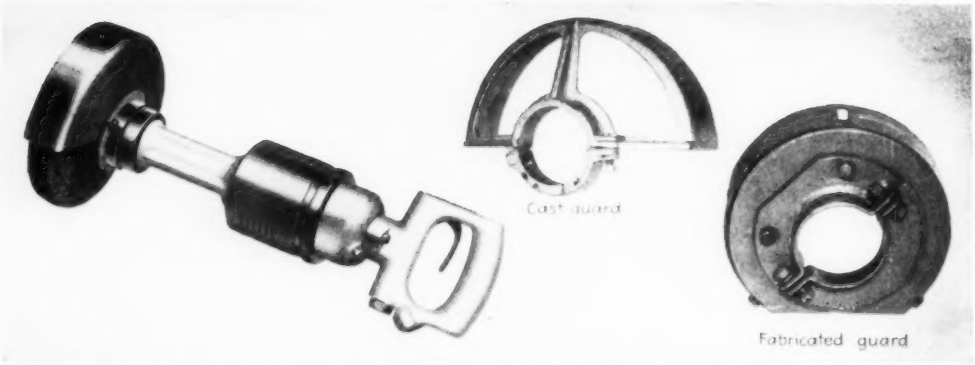
TIMING MOTOR is of the permanet magnet rotor type. It provides an extremely high torque (15 in.-oz) at rated speed. This is of a new flat construction designed to save space. The simple stamped gear case and housing help to keep the thickness of the unit to only $\frac{5}{8}$ inch. Motor drives a group of cams which control various operations.

Self-Aligning Precision Bearings For Concrete Mixer

Bearings for the rotor of the concrete mixer made by Desplaines Concrete Products Company are several feet apart. Loads are heavy, and the bearings are exposed to dirt and severe corrosive conditions in service. These conditions necessitated the use of sealed bearings, and preferably self-aligning units, since the housing is constructed of plate steel and accurate alignment of the journals would add to the cost of manufacture and assembly. Precision ball bearings made by the Stephens-Adamson Mfg. Company were used. These bearings are self-aligning without distortion or loss of effectiveness of the seal. Manufacturing tolerances are less than would have been required with standard bearings, and costs are proportionately less. Here is a case where the designer's knowledge of what the vendor has to offer in the way of components, increases the value of the production dollar. Without this knowledge, the cost of this product would surely be greater.



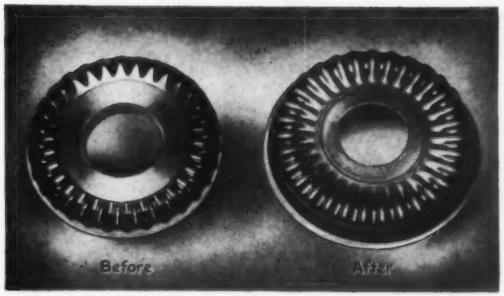
Stamped Wheel Guards 35 Percent Cheaper



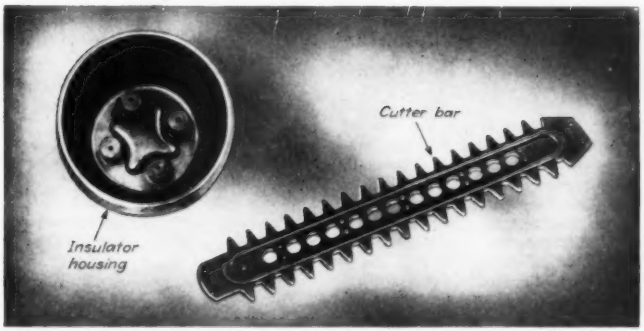
WHEEL GUARD of this portable "Multi-Vane" grinder is now made up of steel stampings: The redesigned 8 in. guard is as much as 75 percent lighter in weight than cast or fabricated guards. The guard is manufactured by Morrison Products Inc. of Cleveland. Both fabricated and cast guards had been used previously. These added considerably to the weight of the portable grinder. They were more expensive as well. Savings in costs of the drawn steel guards range up to 35 percent over those made by other methods. The uniform symmetrical design of the stamped hood also improved the appearance of the product. In the photograph above, the stamped guard is assembled on grinder. Former cast and fabricated guards are shown at the right.

Stamped Parts Lower Product Cost

One factor that keeps parts suppliers on the alert is competition from other manufacturers who use different methods of production. Stamping and forming specialists, for example, are constantly on the lookout for parts that can be produced more economically on a stamping and drawing press than on any other piece of equipment. Taking advantage of such competition will enable designers to keep product costs at the minimum. These three case studies from the files of the Worcester Pressed Steel Company prove the point. In each case, only minor design modifications were required. However, sometimes the resulting savings would justify even major design changes.



BIG SAVINGS in cost and in production time were achieved by redesigning this Godet roller for a nylon spinning machine. Previously the roller was machined from the solid bar stock and then each individual guide slot—of which there are 31—was precision milled separately. Now, the unit is formed from .050 inch gage AISI 1010 steel in 3 operations: Blank and cup, forms slots, and trim-pierce. The savings per machine are considerable since 350 of the rollers are required for each shaft; and furthermore, the weight has been reduced approximately 82 percent.



INSULATOR HOUSING (formerly a casting) and cutter bar (formerly machined from ½ inch stock) are now made by press operations. The reason for converting the insulator housing was to cut weight and cost, and to obtain a body that would not fracture. The cost was the primary consideration on the cutter bar because the teeth were all milled, the holes drilled, and the surface indentations (on the reverse side) were tediously end-milled all around. On the Presteel part, all teeth are press-cut and trimmed, holes are pierced, and depressions and flat surfaces are coined.

Random Notes on Cost Reduction

OCTOBER is *C* month for all McGraw-Hill magazines—*C* in this case standing for cost. *American Machinist, Power, The Operating Engineer, Chemical Engineering*, and each of the others is devoting extra space to the subject of designing, building, and operating products and equipment more economically and more effectively. Although the entire June issue of PRODUCT ENGINEERING was given over to Designing for Lower Costs, the editors plan to follow through on the subject, each month bringing together some of the outstanding methods being applied by design engineers throughout the country.

RUMOR HAS IT that two of the big three automotive manufacturers have experimental cars equipped with fluid magnetic clutches on the proving grounds. If successful, the units probably would be less costly to manufacture than automatic transmissions of the hydrodynamic torque converter type, but indications are that sealing of the units and proper segregation of the magnetic particles may prove to be obstacles in such large-size units.

ONE OF THE MOST EXPENSIVE METALS that could be used for sheet, stampings, and forgings is in the news: Titanium. Although the cost may approach $200 per pound for pure titanium sheet—according to one company engaged in fundamental research on the problem—both private concerns and the government are spending considerable time and money to investigate properties, methods of production and fabrication, and potential applications. One big advantage is the high strength-to-weight ratio of the material which is said to be higher than any other competing metal. Interest is centered on pure titanium and on titanium alloys. At this stage, the latter materials appear to have excellent possibilities.

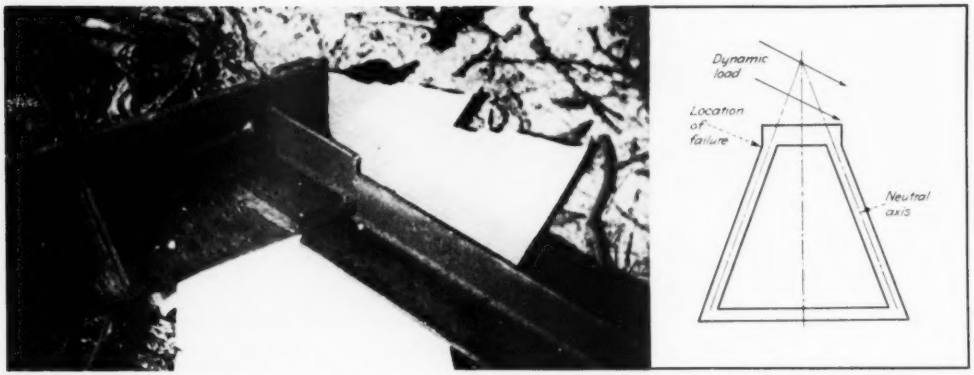


Fig. 1—(Left) Oil well pumping jack frame failure. Further failures were prevented by making photoelastic study of frame stresses. (Right) Layout of pumping jack frame showing location of failure. Lower arrow shows original direction of applied dynamic load; upper arrow shows line of action for load that eliminated bending stresses, leaving only normal tension or compression.

Analyzing Mechanical Failures

Common sense analysis and latest equipment for testing materials are biggest factors in changing mechanical failure information into basis for sound future practice in mechanical part design.

KENNETH N. MILLS
Assistant Chief Mechanical Engineer,
Emsco Derrick & Equipment Company

FINAL MECHANICAL FAILURE is the result of one or more adverse conditions, each of which leaves its characteristic mark. While all mechanical failures are not within the direct control of designers, the majority are, and all are subject to analysis and classification through interpretation of these marks. If the designer studies each failure carefully and discovers all characteristic marks, causes can be determined and avoided in the future.

The most common type of failure is fatigue. At one time fatigue was considered uncontrollable, but now that its most common cause, local overstressing introduced by stress raisers, is known, failures caused by fatigue are controllable. The more complex and less common types of fatigue failures are caused by excessive deflection, high local rigidity, eccentric loading and local concentration of dynamic forces.

In some cases, excessive deflection will cause fretting of the mating surfaces. This type of surface deterioration will create points of stress concentration, and fatigue failures can occur at these stress raisers. Such failures are difficult to avoid, but can be prevented by increasing member sizes or eliminating the usual causes for fretting.

Although fatigue is the most common type of failure, and it is generally recognized after the part has failed, its basic causes are often overlooked in the original design. While points of stress concentration cannot always be visualized and eliminated, they can be kept at a minimum if the stress distribution in the original design is carefully analyzed. One of the best methods for locating points of stress concentration is qualitative photoelastic stress analysis.

Photoelastic Analysis

Photoelastic studies of stress distribution in all basic types of connections will give the designer a gage for evaluating connections and will increase his awareness of possible stress concentrating points. Qualitative photoelastic stress analysis of complete machine elements can be used to check the accuracy of assumptions made in design calculations and will locate points of stress concentration in these parts. After the machine is produced, points of possible high stress, as indicated by photoelastic analysis, can be checked with brittle lacquer and actual values of stress intensity can be determined with strain gages.

If the above outlined procedure had been used in designing the oil well pumping jack frame shown in Fig. 1, the failure shown would not have occured. Additional failures were prevented by applying results of photoelastic stress analysis. The general layout, loading and location of this failure is shown in Fig. 1. In service, the frame was subjected to a dynamic load in the direction indicated by the lower arrow.

The results of a photoelastic stress analysis of this frame are shown in Fig. 2, left. The frame members project a series of bands indicating they are subjected to bending stresses in addition to tension or compression normally existing. The result of moving the load application point to the intersection of the neutral axis of leg-members, as represented by upper arrow in Fig. 1, is shown in Fig. 2, right. Bands that would indicate bending do not exist, and therefore leg members are subjected only to pure tension or compression. Since bending stresses were avoided by moving the point of load application, total stress in all members was materially reduced—and failures were prevented without increasing member sizes.

A typical example of a failure due to excessive local stiffness is shown in Fig. 3. This failure occurred in the center of a walking beam used on an oil well pumping unit. In this machine, the beam carries a large dynamic load and is subjected to moderate impact loads. Failure in this beam was caused by the vertical stiffener between the two flanges of the beam. The stiffener was located at the point of maxi-

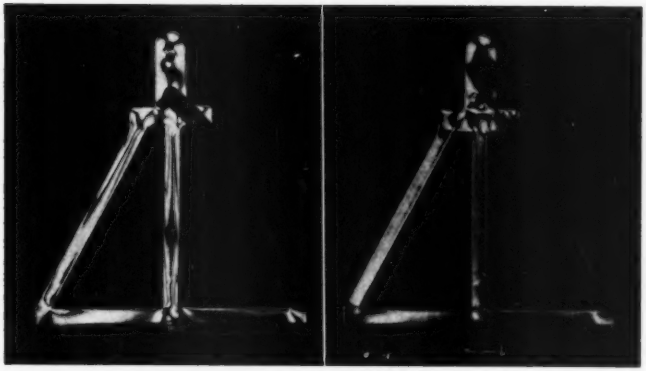


Fig. 2—Photoelastic studies on plastic model of pumping jack frame. Left, original application of load; right, load application that introduces least stresses in leg members. Bands shown on legs at left indicate bending stresses; at right, pure compression.

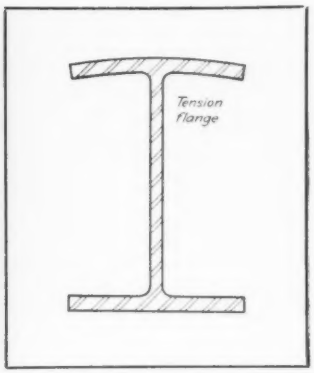


Fig. 3—Oil well pumping unit walking beam that failed because of a stiffener that restrained the tension flange.

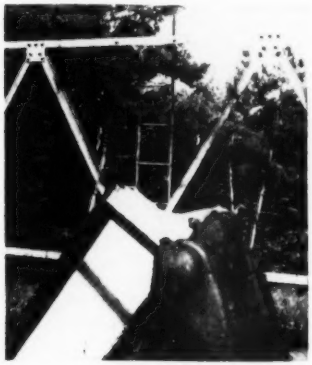


Fig. 4—Action of tension flange when an I-beam is acted upon by a bending load.

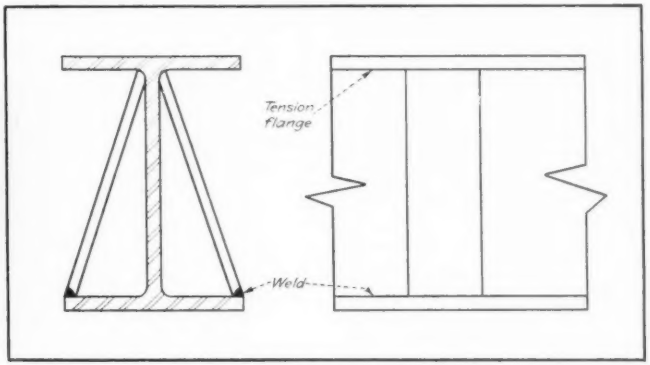


Fig. 5—Design of stiffener that can be used with dynamically load I-beams. It is applied under a pre-compression load and is not welded to tension flange.

mum bending moment and the top flange of the beam was in tension. Since the stiffener was rigidly attached to the entire beam section it restrained the tension flange from its normal flexure at this point.

When a bending load is applied to a beam, its tension flange deflects as shown in Fig. 4. The magnitude of this deflection is a function of the bending stress. If the tension flange is locally restrained from deflecting at a point near the position of maximum bending stress, additional bending stresses will be induced into the tension flange adjacent to the stiffener. These additional stresses exist because the flange deflects at points adjacent to the stiffener but is restrained from flexing at the stiffener. Stresses created by this point of local stiffness add to the tensile stresses and may cause the beam to fail under dynamic loading. Stiffeners can be added to dynamically loaded beams without creating dangerous points of stress concentration if they do not restrain the tension flange. The stiffener design shown in Fig. 5 will accomplish this result, if it is applied under a pre-compression load and is not welded to the tension flange.

As welding offers a method for producing a more efficient connection with increased rigidity, its use for joining machine elements is increasing. If the maximum advantages of welding are to be gained, relative abilities of various types of welded connections to withstand dynamic loads must be known. As heat is used in welding, metallurgical and thermal expansion and contraction considerations are involved, and if not given proper attention can cause weld failures. In arc welding, the metallurgical problems do not arise until carbon content of steel being welded reaches a critical value.

Steels with carbon and manganese contents that meet the requirement that the percentage of carbon plus the percentage of manganese divided by 6 is less than 0.45, can generally be welded without special precautions. If this limitation is exceeded, a martensitic structure will be formed adjacent to the zone of fusion, because of the quenching effect of the base metal. Because this structure is hard and brittle, cracks may occur in this zone during the welding process. If these cracks are not detected they will act as stress raisers and cause the weld to fail in service.

If the weld is subjected to severe contraction stresses, steel meeting the above limits for weldability cannot be welded without special precautions. Steels whose chemical composition exceeds the limits for weldability and where weldments are to be subjected to severe contraction stresses can be welded successfully if the parts are pre-

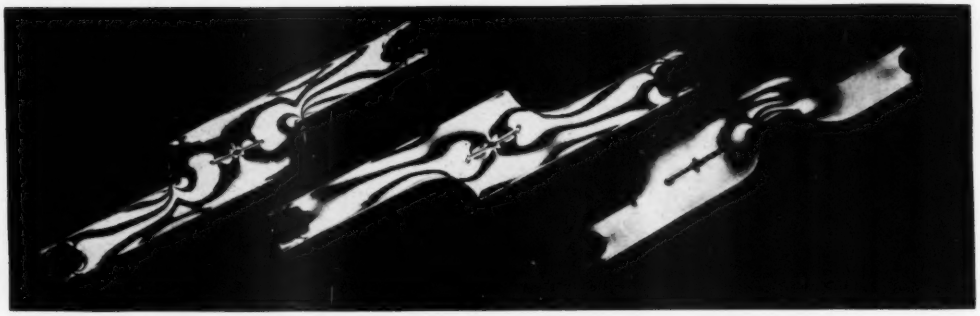


Fig. 6—Photoelastic studies show riveted joint types are not too successful when applied to welding. Left, lap joint with convex weld beads has stress concentration points at toes of welds; middle, concave weld beads avoid stress concentrations but do not eliminate bending stresses; right, bending stresses appear in joggle when lining up neutral axis.

heated. They must be held at the preheat temperature during welding and then slow-cooled. Weldments composed of steels with subcritical amounts of carbon should be given a high temperature stress relieve after welding to remove the stresses induced by welding and to obtain increased ductility at the zone of fusion.

If a weldment is subjected to dynamic loads, the design of all welded joints and maintenance of good welding practice are important. All welds must have complete penetration. They must not be "under-cut" or excessively reinforced, as all of these weld defects are stress raisers and can cause fatigue failures in the welded connections. If maximum economy is to be attained in welded construction, the designer must not think in terms of joint designs used in bolted and riveted construction. These joints require excess material and usually introduce points of stress concentration.

The lap type joint is a typical example of a riveted connection that is commonly used as a welded joint. It is popular because it has double welds and is assumed to be stronger than a butt welded joint with only one weld. A photoelastic analysis of this type welded joint with convex weld beads is shown in Fig. 6, left. There is a crowding of the bands at toes of the welds indicating points of stress concentration. Also, it will be noted that bands exist in the parent material indicating that it is subjected to bending stresses in addition to tensile stresses induced by the applied load. Stress concentration caused by the shape of the weld beads can be reduced by using concave weld beads, as shown in Fig. 6, middle, but the bending stresses cannot be eliminated, because the neutral axis of the two members are not in line.

The neutral axis of the members can be placed in line, if a joggled type joint is used, but the bending stresses are not eliminated with this type joint because they are transferred to the offset section. A photoelastic analysis of this type joint is shown in Fig. 6, right. The butt weld with complete penetration represents the most efficient connection for joining two plates in the same plane, because it does not introduce points of stress concentration or bending stress caused by eccentric loading. Also, it requires the minimum amount of welding time and material.

Another common type of welded connection is the tee joint. A photoelastic analysis of a tee joint with convex beads and incomplete penetration subjected to a tensile load is shown in Fig. 7, left. There is a concentration of bands at the toe of the fillet and at the root of the weld indicating points of stress concentration. A photoelastic analysis of a similar weld with concave weld beads is shown in Fig. 7, right. It will be noted that stress intensity at the toe of the weld has been materially reduced, while stress concentration at the root of the weld is virtually uneffected. Stress concentration at the root of the weld can be eliminated by using a welding procedure which will give complete penetration.

Stress raisers can be created by processing errors such as rough machined surfaces, die marks, grinding cracks etc. The roller chain link shown in Fig. 8 failed because of stress concentration at a notch formed on the inside of the side bars during the bending operation. The nature of stress distribution in this side bar was as

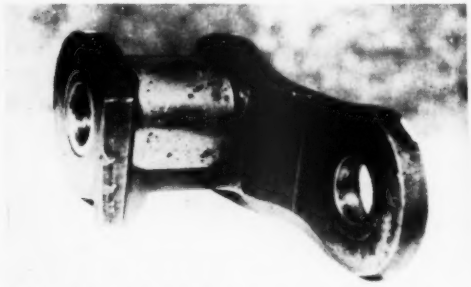


Fig. 8—Roller chain link that failed because of a notch formed during bending operation. Addition of a small radius prevented failure by relieving stress concentration at this point.

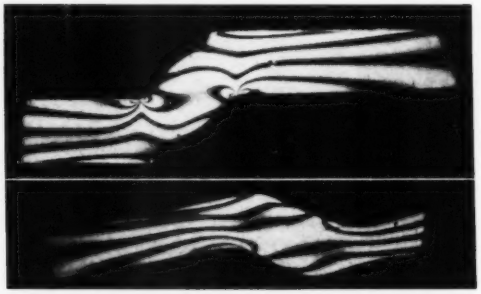


Fig. 9—Photoelastic study of chain link side bar (top) as failure occurred. Same bar (bottom) with radius added prevents stress concentrations. Note the bands concentrated at the notch.

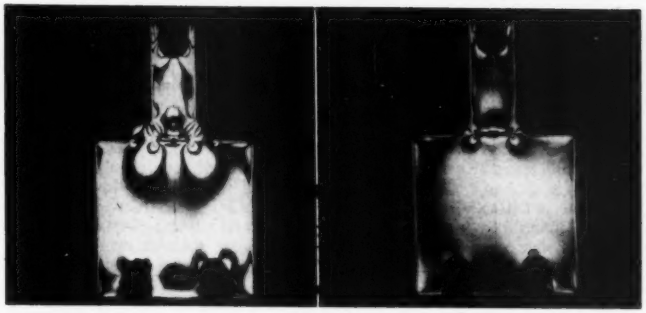


Fig. 7—Tee joint with concave weld beads (right) is better than with convex beads (left). Complete penetration of weld would virtually eliminate stress concentration at the root of the weld.

shown in the photoelastic analysis in Fig. 9, top. Bands are concentrated around the notch, indicating a point of high stress intensity. Result of adding a small radius at the point of stress concentration is shown in Fig. 9, bottom. It will be noted that the point of stress concentration was prevented by adding the fillet.

Failure in Threaded Members

Most common machine elements to fail in fatigue are threaded members such as bolts, cap screws and studs. Screw thread failures are influenced by rigidity of the bolted members, relative rigidities of the bolts and the bolted members and the degree bolt tightness. If the bolted members lack rigidity and deflect under load, load will be applied to the bolt eccentrically. Eccentric loading will induce bending stresses in the bolt in addition to tensile stresses caused by the applied load, thus increasing the total stress in the bolt.

Ability of a threaded member to absorb energy can be increased by reducing the area of the unthreaded section to that of the root area of the threads. This also reduces stress concentration at the last thread. Degree of stress concentration at the last thread can also be reduced by stress guiding grooves, as shown on the right hand end of the screw thread shown in Fig. 10. This photoelastic model is loaded in eccentric tension and also illustrates the beneficial effects gained from thread run out as produced by the throat of a threading die. The stud shown in Fig. 11 had ground threads with no run out, and it failed at the last thread because of the high degree of stress concentration created by this abrupt change in section. Stress guiding grooves or a gradual thread run out would have prevented this failure.

If members joined by bolts are rigid and in intimate contact, initial bolt tension has a material effect on the nature of stresses induced into the bolt by a dynamic load. If the initial bolt tension is just sufficient to bring the surfaces into contact and the connection is subjected to an alternating load, the bolt stress range will be from zero to a maximum. As initial bolt tension is increased, stress range decreases until it approaches zero when the initial bolt tension equals or exceeds the applied load. Since the endurance limit is a function of the range of stress and increases as the range of stress approaches zero, ability of a bolt to resist fatigue failure is increased as initial tension is increased. The effect of initial bolt tension and member stiffness on stress range is analyzed mathematically below.

K_b = Bolt stiffness, lb per in.
K_m = Material stiffness, lb per in.
d_b = Bolt deflection caused by initial load, in.
d_m = Material deflection caused by initial load, in.
Δ = Bolt stretch caused by applied load, in.
F_i = Initial bolt tension, lb
F_w = Increased bolt tension, lb
W = Applied load, lb
$F_i = K_b d_b = K_m d_m$

Assume load W is applied producing a bolt stretch Δ, then:

$$K_b(d_b + \Delta) = W + K_m(d_m - \Delta)$$
$$K_b d_b + K_b\Delta = W + K_m d_m - K_m\Delta$$
As $K_b d_b = K_m d_m$
$$K_b\Delta = W - K_m\Delta$$
$$W = K_m\Delta + K_b\Delta = \Delta(K_b + K_m)$$
$$\Delta = \frac{W}{K_b + K_m}$$

As the increased bolt tension $= \Delta K_b$

$$F_w = \frac{W K_b}{K_b + K_m} = \frac{W}{1 + \frac{K_m}{K_b}}$$

From the above equation it can be seen that if the initial bolt tension equals the applied load, the bolt stress range approaches zero as the member stiffness approaches infinity. Since gaskets, shims and washers all increase elasticity of bolted connections, they increase the range of bolt stress and should be avoided in bolted connections that are to be subjected to dynamic loads.

Bearing Failure Analysis

Some of the most difficult failures to analyze occur in anti-friction bearings. As the basic capacities of all anti-friction bearings are based on stressing the material to a level in excess of the endurance limit, normal bearing failures will be evidenced by surface fatigue failures. Since the more common types of premature failure cause surface fatigue failure, they are difficult to distinguish from normal bearing failures. However, the nature and location of the bearing surface that has failed in fatigue can be used to determine the cause of a premature anti-friction bearing failure.

A straight roller bearing that has failed in normal fatigue will have its race ways spalled across their entire

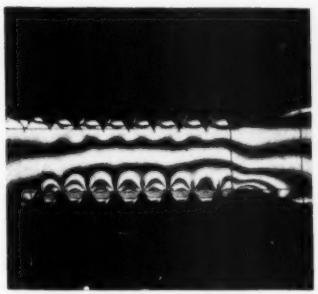


Fig. 10—Photoelastic model of screw thread showing beneficial effects of stress guiding grooves and thread run out.

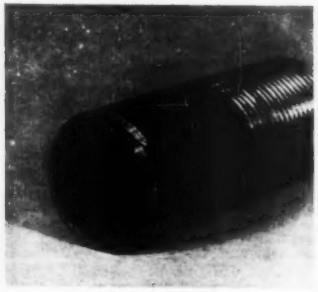


Fig. 11—This stud failed at last thread because of high degree of stress concentration created by abrupt change.

face as shown in Fig. 12. This type of failure will only occur when the race ways are hardened to the proper value. If they are too soft, the rolling surfaces will have the "fish scaled" appearance shown in Fig. 13. Since the characteristic appearance of a normal anti-friction bearing failure is that of surface spalling, this information can be used to analyze the causes for some premature bearing failures. If spalling is concentrated on one side of the rolling surface misalignment is indicated.

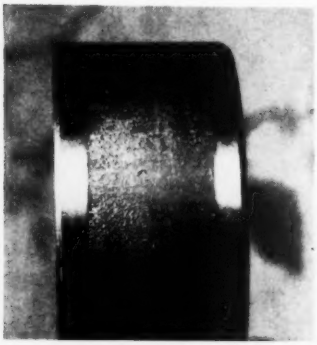


Fig. 12—A straight roller bearing that failed in normal fatigue shows its race ways spalled across entire face.

Fig. 13—"Fish scale" appearance of rolling surface caused by soft race ways.

Fig. 14—Bearing race that failed through abrasive wear caused by badly oxidized lubricant. Water also causes failure.

Preloads can be imposed on a bearing assembly, either purposely or accidently. Preloading is used to increase stability in some high speed guiding spindles and it has been introduced into some assemblies in an attempt to compensate for housing flexibility. As preloading is normally encountered in bearing applications where the bearings are capable of carrying both radial and axial loads, it increases the applied bearing load and causes a reduction in bearing life. When preloading is purposely introduced, the increased load is usually considered in the bearing selection. If preload is accidently introduced, it will cause premature bearing failures. If the preload does not cause excessive deflections, the resulting bearing failure will have the characteristic appearance of a normal bearing failure. If it causes excessive deflection, it will have the appearance of a failure caused by excessive housing or shaft deflection.

Radial type roller bearings are not used in applications requiring preloading because of the difficulty of controlling amount of preloading and the difficulties involved in assembled bearings in a preloaded condition. However, if the bearing fits are too tight, a preloaded condition can be induced into a straight roller bearing application. In addition to causing excessive bearing loads, preloads on a radial type roller bearing can create extremely high lateral thrust loads. These thrust loads will be established when the rolling elements and surfaces are not absolutely free of tapers, and their magnitude will depend on the degree of taper. Magnitude of these forces can be sufficiently great to shift the location of bearing races and has forced bearing races thru the ends of bearing housings. These forces do not exist in bearing applications when the bearing has the proper amount of internal clearance because the rollers are afforded an opportunity to re-align themselves in the unloaded zone.

One of the causes for anti-friction bearing failures that may not result in surface fatigue failure of bearing elements is abrasive wear. Abrasive wear is caused by introduction of contaminating elements into the lubricant. These elements may be acid from oil oxidation, dirt, metal particles, water from condensation and other sources. Effects of acid and water on an anti-friction bearing are identical. Each forms abrasive oxides on the rolling surfaces of the bearing. These abrasive products will lap the bearing surface and increase the internal bearing clearance. This action will cause the bearing to become loose and it disrupts the distribution of load between the rolling elements. Disruption of the load distribution between the rolling elements tends to increase the load per rolling element and decreases the life of the bearing. The bearing race shown in Fig. 14 failed through abrasive wear produced by a badly oxidized lubricant.

The action of moisture or a corrosive lubricant on a bearing that is not rotating is quite different than the action of a corrosive element on a rotating bearing. In stationary bearings the corrosive element will only attack the parts that are in contact, and these points will be severely etched. Since these severely etched zones are below the level of the adjacent material they create points of stress concentration and materially reduce the life of the bearing.

If proper housing and shaft fits are not used in mounting anti-friction bearings, difficulty may be experienced with rotation between one or both of the bearing races and the member carrying the race. If this condition exists, it will cause the member carrying the race, which tends to rotate, to wear at an excessive rate. It may also cause the race to work out of position, if its lateral location is not established by position locks.

Rotation of a bearing race on its mounting surface will be experienced when the load direction rotates or varies widely with respect to a fixed point on the bearing race and the race is not a press fit on the mounting surface. Race rotation will be experienced under these conditions because the race will act as an internal gear on its mounting surface if there is any clearance between the race and its mounting surface. If the load direction is constant and the shaft rotates, the inner race should be a press fit on the shaft. If the load direction is constant and the housing rotates, the outer race should be a press fit in the housing. If the bearing application is such that each of the above conditions exist at various times during the operating cycles or if the load direction varies and one race rotates, both races should be press fit.

While most machine failures are caused by faulty design or workmanship, some result from defective materials. The designer can, by working with the metallurgist, learn to recognize readily failures due to metallurgical defects. He can then inspect intelligently each failure before turning it over for metallurgical examination. The data accumulated by doing this usually leads to a reduced number of failures.

BUCKLING

Of Uniform and Stepped Columns—I

- Procedure for more accurate analysis of buckling than is obtained with handbook formulas, with application to cylinder and piston-rod assemblies.
- Curves that facilitate finding the critical load when initial eccentricity and cross-section shape of the compression member are taken into account.
- Method for rapid determination of the length of a uniform cross-section bar that is equivalent in elastic behavior to a pin-jointed, single-step column.

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Research Engineer
Bucyrus-Erie Company

HANDBOOK FORMULAS for the allowable stresses as a function of the slenderness ratio of compression members are based on assumptions covering such factors as initial eccentricity and cross section shape. A factor of safety is also included in these formulas, and they represent a considerable compromise to make them suitable for a variety of buckling cases. Formulas of this kind are very useful for calculations to which they are tailored, but many buckling problems require closer investigation. Where greater accuracy is required the following procedure is recommended:

1. Determine the critical load; that is, the load that first causes the extreme fiber stress to reach the yield point, for the actual, or closely estimated, conditions.

2. Apply the proper factor of safety to the critical load to find the allowable working load.

3. Establish the maximum stress under the working load and check whether it is within permissible limits to safeguard against fatigue failure.

Assumptions

This investigation applies directly to pin-jointed bars; it is assumed that the characteristics of the cross section are such as to bring about the smallest critical load for buckling in a plane perpendicular to the axes of the pins. For built-in columns or for the relatively rare cases where the stiffness characteristics favor buckling in a plane not perpendicular to the axes of the pins, the analysis has to be made for an adjusted length of the compressive member. This adjusted length is to be taken as the distance between points of inflection of the elastic line, and the points of inflection must be treated as pin-joints.

It is assumed that the pins are parallel and remain parallel as the load is applied. It should be investigated from case to case whether this assumption holds, and if necessary, the pins should be strengthened. If appreciable pin deflection occurs, as may happen particularly with overhung pins, serious secondary stresses may be caused and lead to a reduction of the critical load.

Symbols used in this article are:

I = Axial moment of inertia.
A = Area of cross section.
a = Partial area of cross section.
$S.M.$ = Section modulus.
r = $\sqrt{I/A}$ = Radius of gyration.
z = $S.M./Ar$ = Section Factor (Shape factor of cross section).
l = Length of column with uniform cross section.
L = Length of stepped column.
b, c = Lengths of individual parts of stepped columns.
e = No-load eccentricity (or initial eccentricity) at center of uniform column.
e_j = No-load (or initial) eccentricity at joint of stepped column.

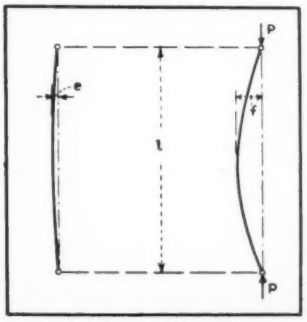


Fig. 1—Buckling of a pin-jointed bar with uniform cross-section.

f = Eccentricity at center of column under compressive force P.
η = e/l = Initial eccentricity ratio.
P = Compressive force.
P_e = Euler's load for elastic buckling.
E = Modulus of elasticity.
σ = P/A = Average compression stress over cross section.
σ_{tot} = Sum of average compression and bending stress = extreme fiber stress.
σ_e = P_e/A = Stress under Euler's load for elastic buckling.
σ_{yp} = Yield point stress.
F = Factor of safety.
x, y = Rectangular coordinates (see Fig. 8).

Critical Load of Bars With Arbitrary, but Constant Cross Section

Consider a compressive force P acting on a pin-jointed bar whose axis represents a slight sine curve, Fig. 1. Due to the action of the compressive force, the initial eccentricity e at the center is increased to f; the new axis of the bar is again a sine curve. The bending moment at the center is Pf, and the bar is in equilibrium when the deflection at the center caused by the bending moments along the bar is equal to $f - e$. This deflection is

$$Pf\left(\frac{l^2}{\pi^2 IE}\right) \tag{1}$$

from which

$$f = \frac{e}{1 - \frac{Pl^2}{\pi^2 IE}} \tag{2}$$

The deflection f becomes theoretically infinite when

$$P = \frac{\pi^2 IE}{l^2} = P_e \tag{3}$$

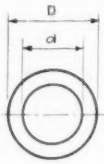
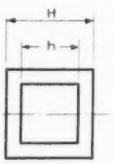
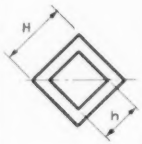
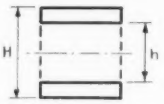
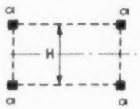
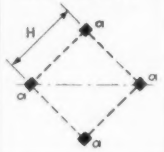
P_e is the well known Euler load for elastic buckling.

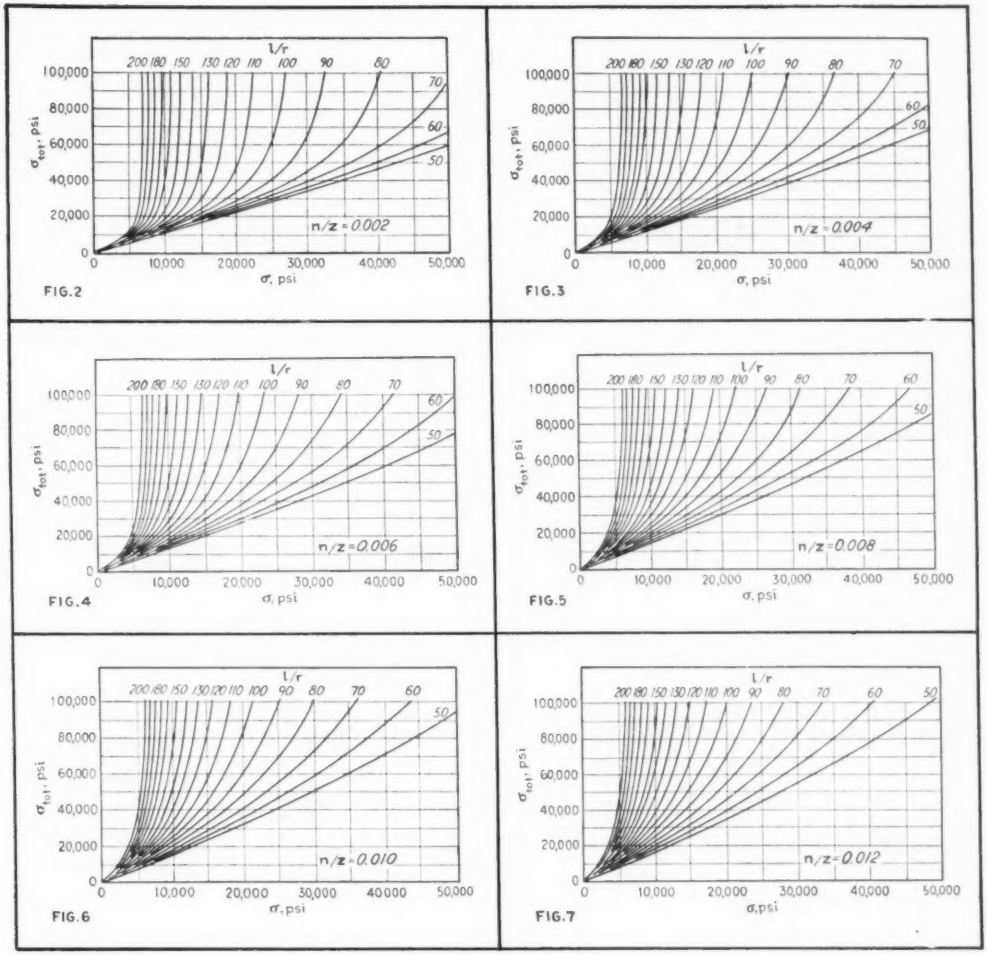
Eq (2) can be rewritten as

$$f = e\left(\frac{P_e}{P_e - P}\right) \tag{4}$$

where the factor $P_e/(P_e - P)$ is com-

TABLE I — VALUES OF THE FACTOR Z FOR VARIOUS COMMON CROSS-SECTIONS

Section	Hollow circle	Hollow square		Two rectangles properly braced together	Four small elements of area a properly braced together		Angle 6×6×½ in.	
		Across flats	Across corners		Rectangular arrangement across flats	Square arrangement across corners	Axes 1-1 and 2-2	Axis 3-3
								
I	$\frac{\pi}{64}(D^4-d^4)$	$\frac{H^4-h^4}{12}$		$\frac{b}{12}(H^3-h^3)$	aH^2		19.9 in.^{4}	8.01 in.^{4}
A	$\frac{\pi}{4}(D^2-d^2)$	H^2-h^2		$b(H-h)$	$4a$		5.75 in.^{2}	5.75 in.^{2}
r	$\frac{1}{4}\sqrt{D^2+d^2}$	$\frac{1}{\sqrt{12}}\left(\sqrt{H^2+h^2}\right)$		$\frac{1}{\sqrt{12}}\left(\sqrt{H^2+Hh+h^2}\right)$	$\frac{H}{2}$		1.86 in.	1.18 in.
Ar	$\frac{\pi}{16}\left(\sqrt{\frac{D^4-d^4}{D^2+d^2}}\right)$	$\frac{1}{\sqrt{12}}\left(\sqrt{\frac{H^4-h^4}{H^2+h^2}}\right)$		$\frac{b}{\sqrt{12}}\left(\sqrt{\frac{H^3-h^3}{H^2+Hh+h^2}}\right)$	$2aH$		10.70 in.^{3}	6.78 in.^{3}
S.M.	$\frac{\pi}{32}\left(\frac{D^4-d^4}{D}\right)$	$\frac{1}{6}\left(\frac{H^4-h^4}{H}\right)$	$\frac{\sqrt{2}}{12}\left(\frac{H^4-h^4}{H}\right)$	$\frac{b}{6}\left(\frac{H^3-h^3}{H}\right)$	$\approx 2aH$	$\approx\sqrt{2}aH$	4.6 in.^{3}	3.37 in.^{3}
z=S.M./Ar	$0.500\left(\frac{\sqrt{D^2+d^2}}{D}\right)$	$0.5774\left(\frac{\sqrt{H^2+h^2}}{H}\right)$	$0.4083\left(\frac{\sqrt{H^2+h^2}}{H}\right)$	$0.5774\left(\frac{\sqrt{H^2+Hh+h^2}}{H}\right)$	≈ 1.0000	≈ 0.7071	0.430	0.497
Special cases	Solid circle; d=0 z = 0.5000	Solid square; h=0 z = 0.5774	Solid square; h=0 z = 0.4083	Solid rectangle; h=0 z = 0.5774				
	Very thin wall circle d≈D z≈0.7071	Very thin wall square h≈H z≈0.8166	Very thin wall square h≈H z≈0.5774	Very thin sheets properly braced together h≈H z≈1.0000				



Figs. 2-7—These curves enable the rapid determination of σ, the average compression stress over the cross section, for various l/r (slenderness ratios) and n/z (eccentricity-shape factors) ratios, and extreme fiber stresses. E equal 29,600,000 lb per sq inch.

monly referred to as the magnification factor for initial deflections. This magnification factor can be expressed in terms of the average compression stress $\sigma = P/A$ and the Euler stress $\sigma_e = P_e/A = \pi^2 E/(l/r)^2$:

$$\frac{f}{e} = \frac{\sigma_e}{\sigma_e - \sigma} \tag{5}$$

The total stress σ_{tot} at the extreme fiber is the sum of the average compression stress σ and the bending stress $Pf/S.M.$:

$$\sigma_{tot} = \sigma + \frac{Pe}{S.M.}\left(\frac{\sigma_e}{\sigma_e - \sigma}\right) \tag{6}$$

The section modulus can be expressed as

$$S.M. = Azr \tag{7}$$

where A is the area of cross section, r the radius of gyration, and z a numerical factor depending on the shape of the cross section. The value of the factor z for several cross sections is shown in Table 1. Substituting equation (7) in equation (6) leads to

$$\sigma_{tot} = \sigma\left(1 + \left(\frac{e}{zr}\right)\frac{\sigma_e}{\sigma_e - \sigma}\right) \tag{8}$$

In most cases, the initial eccentricity e at the center of the bar is stated in terms of the length of the bar, that is

$$e = nl \tag{9}$$

Combining Eqs (8) and (9), the total stress at the extreme fiber can be expressed as

$$\sigma_{tot} = \sigma\left(1 + \frac{n}{z}\frac{l}{r}\left(\frac{\sigma_e}{\sigma_e - \sigma}\right)\right) \tag{10}$$

The curves of Figs. 2 to 7, inclusive, show the relations between σ and σ_{tot} for a wide range of n/z and l/r values.

The bar is critically loaded when the maximum fiber stress reaches the yield point stress, that is

$$\sigma_{tot} = \sigma_{yp} \tag{11}$$

The critical load is found as

$$P_{cr} = A\,\sigma \tag{12}$$

where σ is determined by Eqs (10) and (11), or curves of Figs. 2 to 7.

The Critical Load Of Stepped Columns

Equivalent uniform columns are established mathematically and their critical loads calculated by the method just described in the case of columns consisting of two parts with different cross section, Fig. 8C. The junction between the two parts is assumed as stiff. The elastic lines of the two parts are again taken as sine curves; at their junction the two sine curves must be tangent to each other and their curvature must be inversely proportional to the respective stiffness.

Assume two bars of length l_1, and l_2, stiffness I_1 and I_2, an initial deflection of the sine-curve axes e_1 and e_2, respectively, Fig. 8A, and require that they have the same Euler load for elastic buckling:

$$P_e = \frac{\pi^2 I_1 E}{l_1^2} = \frac{\pi^2 I_2 E}{l_2^2} \tag{13}$$

The relation between the lengths of the bars is thus established as

$$l_2 = l_1 \sqrt{\frac{I_2}{I_1}} \tag{14}$$

When both bars are subjected to the same compressive force P, their deflections at the center increase from the initial values e_1 and e_2 to the values f_1 and f_2, respectively, whereby (from Eq 4):

$$\frac{f_1}{e_1} = \frac{f_2}{e_2} = \frac{P_e}{P_e - P} \tag{15}$$

The axes of both bars are still sine curves and the deflection at any point can be calculated from the deflection at the center.

Now assume that before any load is applied, the second bar is moved so that its end points are in line with the end points of the first bar, and that the two bar axes are tangent to each other at point T, Fig. 8B. Then, if a compressive force P is applied, the deflection of both bars increases by magnification factor $P_e/(P_e - P)$, and the two axes still have a common point T_p. Furthermore, they are still tangent to each other at point T_p. It is thus realized that for any load P the conditions as to deflection, slope, and bending moment at point T_p are identical for both bars. It would, therefore, not make any difference in the behavior of section TB_1 of the first bar, if its section TC_1 was replaced by section TC_2 of the second bar. The critical load of the stepped bar B_1TC_2 is exactly the same as the one for the two original bars. Similar considerations hold for the stepped bar B_2TC_1. Hence a bar of length l_1 and inertia I_1, (or a bar of length l_2 and inertia I_2) has the same Euler load for elastic buckling as the stepped bars B_1TC_2 and B_2TC_1.

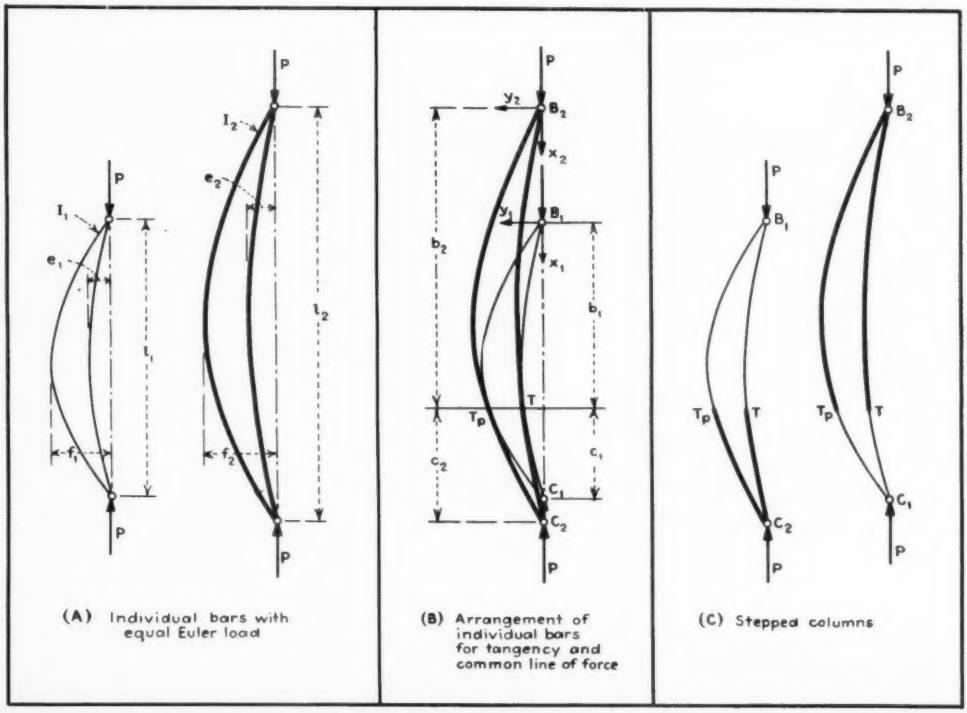
In practical problems, the lengths b_1 and c_2 (or c_1 and b_2) of the individual parts and their respective inertias I_1 and I_2 are known, (Fig. 8B), and the equivalent length l_1 is to be established. The relations are as follows:

EQUATIONS FOR FIRST BAR

General:

$$y_1 = \left(\frac{P_e}{P_e - P}\right) e_1 \sin \frac{\pi x_1}{l_1}$$

$$\frac{dy_1}{dx_1} = \left(\frac{P_e}{P_e - P}\right) \frac{\pi e_1}{l_1} \cos \frac{\pi x_1}{l_1}$$



(A) Individual bars with equal Euler load

(B) Arrangement of individual bars for tangency and common line of force

(C) Stepped columns

Fig. 8—Sketches showing nomenclature and loading for developing equations used to determine critical load of stepped columns.

At Point T_p:

$$y_1 = \left(\frac{P_e}{P_e - P}\right) e_1 \sin \frac{\pi b_1}{l_1}$$

$$\frac{dy_1}{dx_1} = \left(\frac{P_e}{P_e - P}\right) \frac{\pi e_1}{l_1} \cos \frac{\pi b_1}{l_1}$$

EQUATIONS FOR SECOND BAR

General:

$$y_2 = \left(\frac{P_e}{P_e - P}\right) e_2 \sin \frac{\pi x_2}{l_2}$$

$$\frac{dy_2}{dx_2} = \left(\frac{P_e}{P_e - P}\right) \frac{\pi e_2}{l_2} \cos \frac{\pi x_2}{l_2}$$

at Point T_p

$$y_2 = \left(\frac{P_e}{P_e - P}\right) e_2 \sin \frac{\pi b_2}{l_2}$$

$$\frac{dy_2}{dx_2} = \left(\frac{P_e}{P_e - P}\right) \frac{\pi e_2}{l_2} \cos \frac{\pi b_2}{l_2}$$

The condition for a common tangent at point T_p is expressed by

$$y_1 = y_2 \quad \text{at } T_p \tag{16}$$

and

$$\frac{dy_1}{dx_1} = \frac{dy_2}{dx_2} \quad \text{at } T_p \tag{17}$$

from which

$$\frac{y_1}{\frac{dy_1}{dx_1}} = \frac{y_2}{\frac{dy_2}{dx_2}} \quad \text{at } T_p \tag{18}$$

or

$$\frac{l_1}{\pi} \tan \frac{\pi b_1}{l_1} = \frac{l_2}{\pi} \tan \frac{\pi b_2}{l_2} \quad \text{at } T_p \tag{19}$$

Hence,

$$\tan \frac{\pi b_2}{l_2} = \frac{l_1}{l_2} \tan \frac{\pi b_1}{l_1} = \sqrt{\frac{I_1}{I_2}} \tan \frac{\pi b_1}{l_1} \tag{20}$$

and

$$\frac{\pi b_2}{l_2} = \text{arc tan} \left(\sqrt{\frac{I_1}{I_2}} \tan \frac{\pi b_1}{l_1}\right) \tag{21}$$

or

$$b_2 = \frac{l_1}{\pi} \sqrt{\frac{I_2}{I_1}} \text{arc tan} \left(\sqrt{\frac{I_1}{I_2}} \tan \frac{\pi b_1}{l_1}\right) \tag{22}$$

The distance

$c_2 = l_2 - b_2$ is

$$c_2 = l_1 \frac{I_1}{I_2} \left[1 - \frac{1}{\pi} \text{arc tan} \left(\sqrt{\frac{I_1}{I_2}} \tan \frac{\pi b_1}{l_1}\right)\right] \tag{23}$$

This transcendental equation has been solved for a number of cases, and the results are presented in the curves of Fig. 9. For convenience, it is assumed that $I_1 \leq I_2$, but imposing this condition in no way restricts the validity of the solution. (24)

The initial eccentricity of the stepped column is first to be figured in inches (generally as a percentage of the total length), and then the initial eccentricity ratio n to be introduced into the calculations has to be based on the length of the equivalent bar (Eq 9). Therefore, n is generally greater than the percentage of initial eccentricity of a stepped column, and this procedure is somewhat on the safe side. When warranted, greater accuracy is obtained by making the initial end slope of the equivalent bar equal to the end slope of part b_1 of the stepped column.

The initial eccentricity at the joint is

$$e_j = e \sin \frac{\pi b_1}{l_1} \tag{25}$$

The maximum fiber stress of a stepped column may occur in either part. Unless it is obvious which has the higher stress, both parts should be checked. The two cases are treated as follows:

a) If the part with the smaller stiffness I_1 is shorter than half the equivalent length l_1, that is

$$b_1 \leq l_1/2 \tag{26}$$

it has to be checked at the joint. In this case, e_j is to replace e in formulas 8, 9, and 10, and Figs. 2 to 7 are to be used accordingly. The part with the greater stiffness is to be checked for the full initial eccentricity.

b) If the length of the part with the smaller stiffness I_1 is equal or greater than half the length of the equivalent bar, that is

$$b_1 \geq l_1/2 \tag{27}$$

it has to be checked for the full initial eccentricity. The part of greater stiffness I_2 is then to be checked for the joint, using the initial eccentricity at the joint e_j. In this instance, it will generally be found that the part with the smaller stiffness is stressed higher.

Final part of this discussion will appear in the November number. The method described above is applied to various buckling problems.

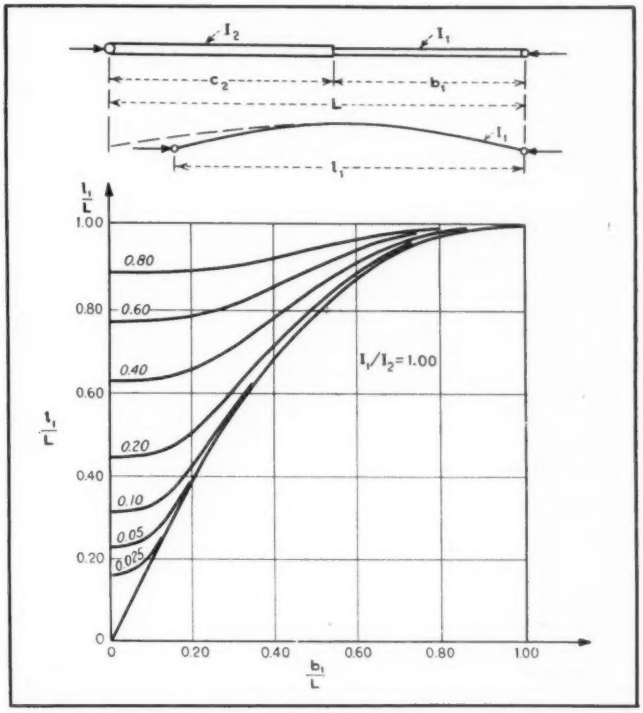


Fig. 9—Curves for determination of l_1, the length of a uniform cross-section column equivalent in action to a stepped column of length L. These curves represent solutions of the transcendental equation (23), thus simplifying buckling calculations.

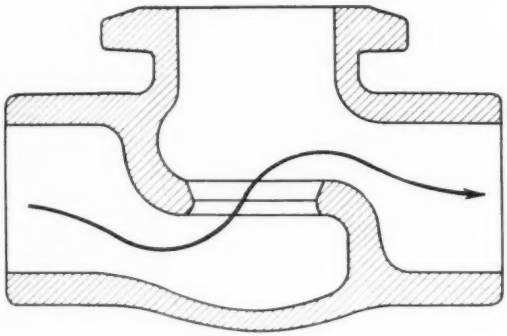
REFERENCES

1. S. Timoshenko, "Theory of Elastic Stability," McGraw-Hill Book Company, 1936.

2. D. H. Young, "The Rational Design of Steel Columns," *Proceedings*, American Society for Civil Engineers, Vol 60, 1934, p 1421–1450. (Excerpt from Doctor's Thesis, University of Michigan, 1934)

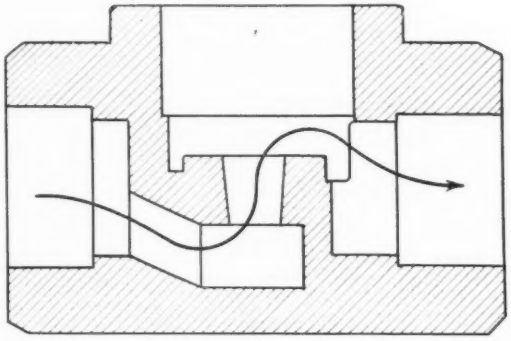
Flow Diagrams for Several

GLOBE VALVES are primarily for throttling and close regulation of flow. Tight closure is possible. This type of valve is suitable for frequent opening and closing. Because of their high pressure drop, even when wide open, they should not be used where unrestricted flow is desired. Globe valves are suitable for regulating liquids or gases. The occasional presence of small amounts of suspended matter can be tolerated. Where extremely close regulation of flow is required, the needle valve type of globe valve may be used.



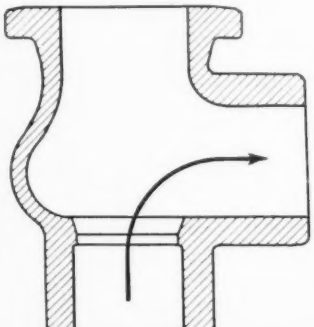
Globe Valve

ANGLE VALVES are designed to combine the valving action of a globe valve with the change in direction obtained from a 90 deg fitting. The pressure drop in an angle valve is less than the combined pressure drop of a globe valve together with an elbow in series. Further advantages are derived from a reduction in the number of joints in the line. When extremely close regulation of the flow is required, the needle valve type of angle valve may be used.

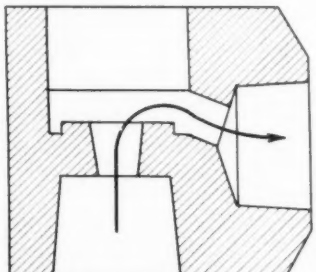


Globe Type Needle Valve

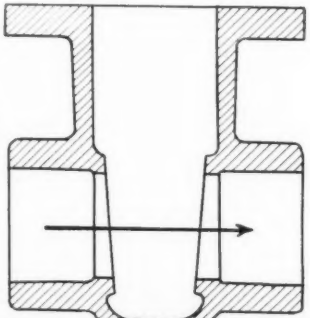
GATE VALVES are advantageous where low pressure drop and unobstructed flow are desired. They are not usually used for close regulation of flow, because high velocity flow through, partly opened valve would cause excessive wear on seats and disks. Since in normal service, they are either fully open or fully closed, the time required for opening and closing is about twice that for opening and closing a globe valve. They are suitable for



Angle Valve



Angle Type Needle Valve



Gate Valve

Types of Valves

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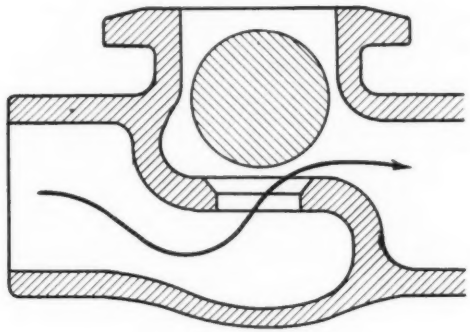
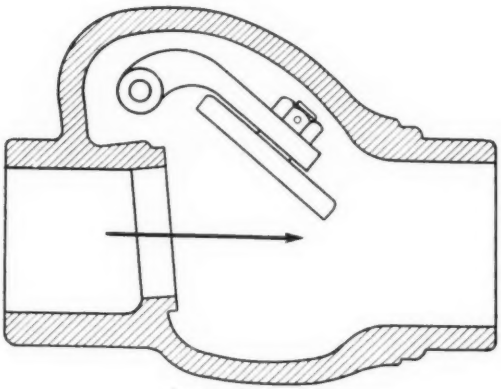


Ball Check Valve



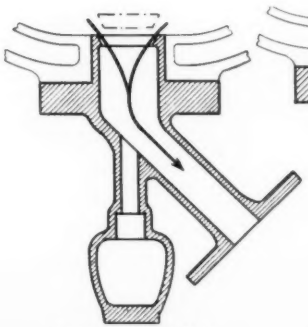
Swing Check Valve

gases and liquids without suspended foreign matter. Suspended foreign matter would tend to lodge on seats and cause damage during closing of valve.

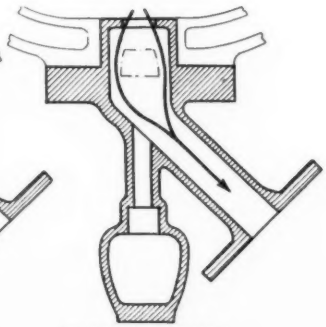
CHECK VALVES prevent reversal of flow through a line. They are used as safety equipment to protect pumps or to prevent drainage of stored liquids. In the swing check valve, flow in the desired direction swings the disk up to open the valve. Flow in the wrong direction swings the disk down to close the valve. In the ball check valve, flow in the desired direction lifts the ball to open the valve, and flow in the wrong direction forces the ball into a position closing the valve.

TANK VALVES are designed to control liquids in tanks. The flow through a raised disk type tank valve is greater than that through a flush type tank valve of the same size. However, agitators or other mechanisms in the tank might damage or be damaged by an open raised disk type tank valve. To overcome this difficulty, the flush type valve, in which the disk is pulled into the valve body, can be used.

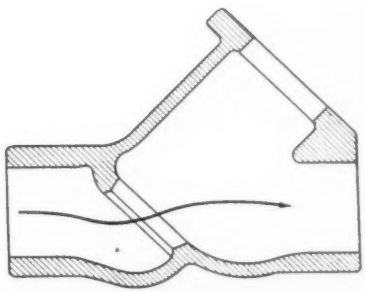
THE Y VALVE is a compromise between the gate valve and the globe valve. The low pressure drop advantage of the gate valve is combined with the tight closure and suitability for frequent opening and closing of the globe valve. Y valves may be used for throttling purposes or for close regulation of the flow.



Raised Disk Tank Valve



Flush Type Tank Valve



Y Valve

Mechanical Computing Mechanisms—III

Continuing the analysis of analog mechanisms to perform mathematical operations. Multiplication, division, integration and differentiation devices and their operation are compared.

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THE SIMPLEST MULTIPLICATION to mechanize is multiplication of a variable by a constant. That is, $y = cx$, which may be done by a gear ratio equal to the required c for rotary variables, or by a simple lever system for straight line motion.

The problem of multiplying two variables is more complex. The form of this equation is $xy = cw$. Four possible means of solving this equation are: similar triangles method, logarithmic method, slide-link and slide multiplier. A mechanism based on the principle of similar triangles is pictured in Fig. 8(A). In this, the lengths x and y are proportional to input quantities and the length a is fixed, as it was for the mechanism shown in Fig. 5(D) PRODUCT ENGINEERING, Sept. 1949. From Fig. 8(A),

$$\frac{x}{w} = \frac{a}{y} \quad \text{or} \quad xy = aw$$

This mechanism provides a theoretically exact solution to the problem of multiplying two variables and may be constructed to permit both variables to change algebraic sign. Care should be taken to prevent the mechanism from reaching a self-locking condition. The guides should be designed to prevent cocking of the links, which would introduce excessive friction; and the construction should be such that when the linkage is transmitting load there will be no spreading of the slide.

The pins can be replaced by small ball bearings, and theoretically the ball bearing will not roll because the slide is touching the bearing at two points. But in actual construction there is always some clearance, and the ball bearing tends to roll rather than slide.

The space requirements for this type of multiplier are relatively large in two dimensions.

Logarithmic Method

A second, theoretically exact method for multiplying is to add the logarithms of each input variable. The log is taken from a cam; the rotational input represents x and y, and the motions of the two followers (log x) and (log y) respectively. Adding these two functions by one of the methods previously described (the slide type, Fig. 7(D), is usually most appropriate), gives the output

$$(\log x) + (\log y) = \log xy$$

and the output of the differential, log xy, actuates an antilog cam. The motion of the cam follower, Fig. 8(B), represents the value of the answer (xy).

This method has several disadvantages. Neither variable may be permitted to reach zero or negative values, or even to approach zero, since the log of zero is indeterminate. Trouble will ensue if the value of the variable becomes less than 1.0, since beyond this point the log becomes negative. If such a condition is unavoidable, the method still may be used in the design if both sides of the equation can be multiplied by a factor so chosen as to make the minimum value of the variables always greater than 1.0. For example, to multiply w equals xy where

$$1 \leqq y \leqq 5 \text{ and } 0.5 \leqq x \leqq 3$$

if both sides are multiplied by 3

$$3w = 3x\,(y)$$

$\log 3 + \log w = \log 3x + \log y$, and the cam becomes actually a log $3x$ cam. The answer taken from the antilog cam is clearly $3w$; but this may be accounted for in choosing the scale factor of w.

Approximate Method of Multiplication

The mechanism shown in Fig. 8(C) is a simple form of an approximate multiplier. It may be constructed from a minimum number of parts, and it finds use in light service and where a limited known error is acceptable. This device mechanizes the equation $w = xy$, where x is the radius of the input arm and y is the input angle.

The slot in the rotating input arm is a circular arc of radius L about the point ($xy = o$) on the output slide. This position of the input arm is taken as $y = o$; at this position the variable x may take on all values within its range without affecting the output. The pivot point of the rotating arm is chosen as $x = o$; similarly, at this point y may take on all values without affecting the result. A layout is required to determine the magnitude of errors inherent in any given mechanism of this type.

This multiplier has the disadvantage of requiring considerable space in two directions for reasonable accuracy; it has the advantage of simple construction.

Another type of linkage which may be used for multiplication is shown in Fig. 8(D). It is somewhat like a similar triangle multiplier except that two of the slides have been replaced by rotary motions. It has the disadvantage of having one of the three scales non-linear. However, the designer may choose which scale is to be non-linear. Also in Fig. 8(D) an equation is given that shows the trigonometric relations between the variables used in determining the y scale.

For example, the linkage is to mechanize the equation w equals xy, where the distance between pivots, c, is equal to 2.000 in. It is desired to find the distance y when variable y is equal to two units. Assume the scales of w and x have the same scale factor of 5 units per in. To find the distance y, for y equals 2 units, assume any value of w, x, that satisfies w equals $2x$; for example, w equals 10, x equals 5; then for

$w = 10$ units $= 2.000$ in.
$x = 5$ units $= 1.000$ in.

$$w = \frac{xy}{c - y}$$

$$2.000 = \frac{(1.000)\,y}{(2.000) - y}$$

or $\quad y = 0.750$ in. $\quad (y = 2$ units$)$

Division

While the mechanisms for multiplication are capable of handling zero and negative values of the input vari-

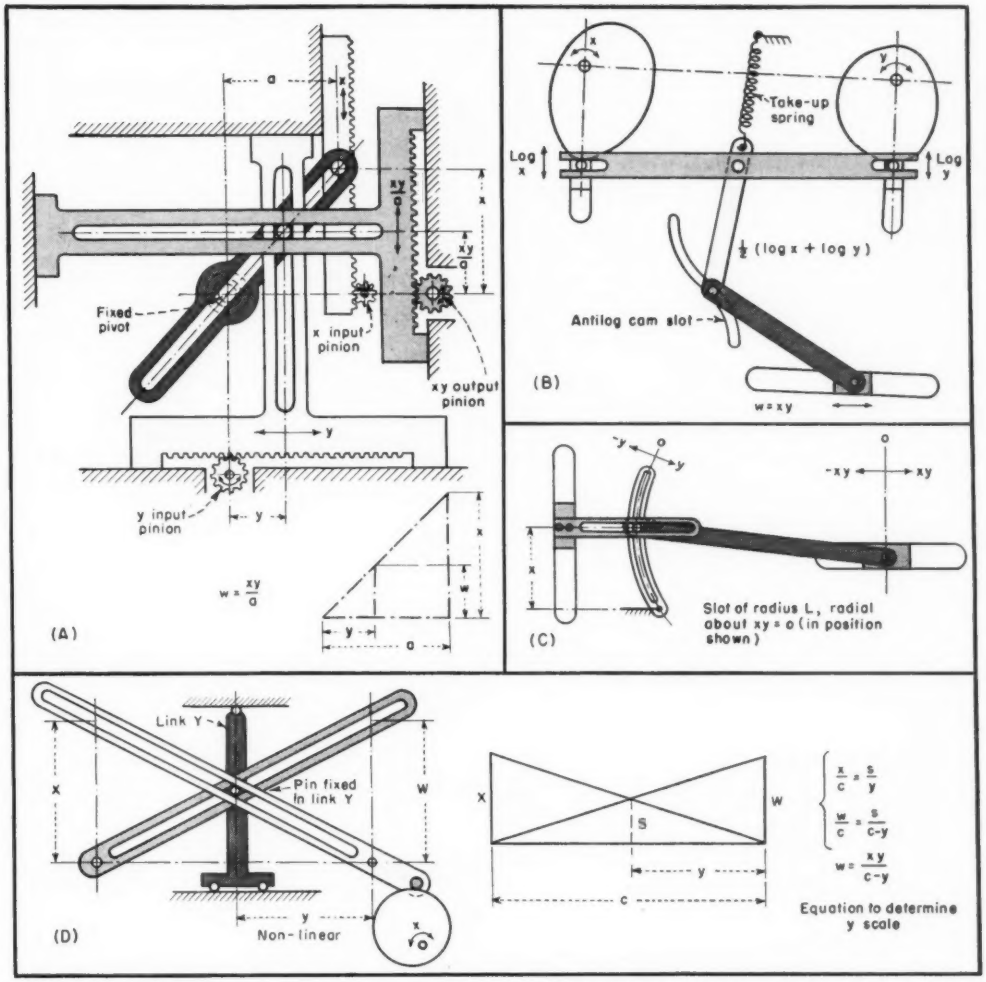
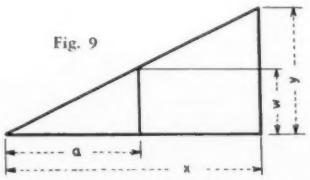


Fig. 8—Multiplication mechanism based on different principles: (A) Similar triangles multiplier. (B) Logarithmic multiplier. (C) Slide-link multiplier, approximate only. (D) Slide multiplier having one non-linear scale.

able, the application of these mechanisms to division are limited by the impossible condition of dividing by zero and the impractical condition of dividing by numbers close to zero. The second condition produces very large values in the answer and results in a small overall scale factor in a computer of reasonable size. With these limitations in mind, and with careful consideration given to scale factors, and possible locking conditions, sometimes it is possible to reverse a multiplying unit and use it for division. For example, consider a line diagram, Fig. 9, of a similar triangle multiplier. From the diagram it can be seen that, as x approaches 0, w increases towards infinity, and when y equals 0, x may vary at will without affecting the answer, w.

Fig. 9



It is possible also to use a log cam multiplier for division. The only change required is that the differential should subtract the logs instead of adding them. In another method, with considerably less limitation, the reciprocal of one input is computed and multiplied by the other variable in accordance with the equation

$$w = (x)\,\frac{1}{y}$$

The reciprocal function, generated with a cam, experiences the same difficulties of discontinuity at and close to zero. This time it results in a very steep cam rise which is sometimes too steep for good camming action.

Division may be performed by using a multiplier and a servo motor,

but this arrangement represents more mechanism and still suffers from the inability to approach zero efficiently. Referring to Fig. 10, a servo motor drives one input w to a multiplier; the other input to the multiplier is the quantity y. The multiplier answer yw is fed to a differential where the other variable x is subtracted from it; that is, the output of the differential is $yw - x$. The follow-up control on the differential causes the servo motor to drive so that $yw -$ *equals* 0 at all times, or w equals x/y.

If y equals 0, the output from the multiplier is zero. If x has a finite value, the differential will give an error signal to the servo motor, but, regardless of the value of w fed into the multiplier, the output is zero. The

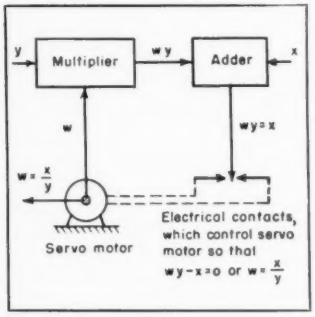


Fig. 10—Division mechanism using a multiplier and servo motor. This device, too, is limited by inability to approach zero efficiently.

signal will in effect attempt to drive the value of w to infinity, or until the mechanism drives to the limit stops.

Integration

The classic two-disk integrator, pictured in Fig. 11(A), consists of a smooth disk, A, rotated by an input variable θ, and another output disk, B, perpendicular to, and spring-loaded against disk A. The radial displacement of disk B from the center line of rotation of disk A is the input variable y. Assuming perfect non-slipping contact between the rotations of the disks, and perfect slipping as disk B moves radially along disk A, the arc $y\,d\theta$ on disk A equals the arc $r\,dw$ on disk B.

Then

$$dw = \frac{1}{r}\,y\,d\theta$$

$$w = \frac{1}{r}\int y\,d\theta$$

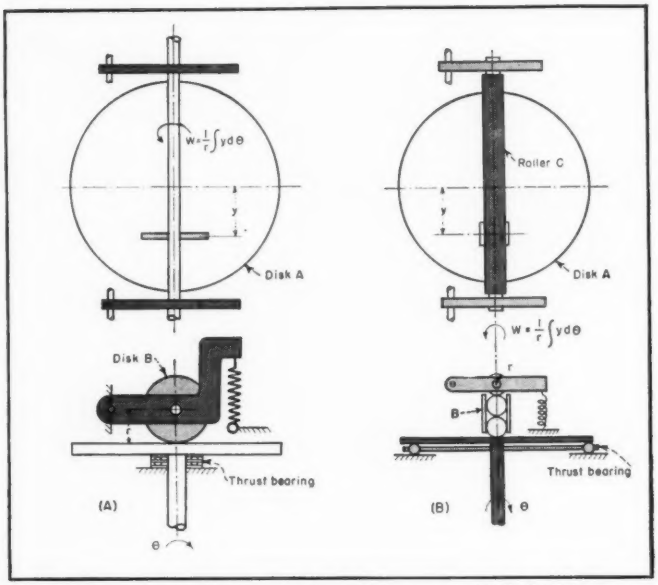


Fig. 11—Two types of integrators. (A) Two-disk integrator. (B) Ball-disk integrator, which overcomes some of the inherent difficulties in two-disk type.

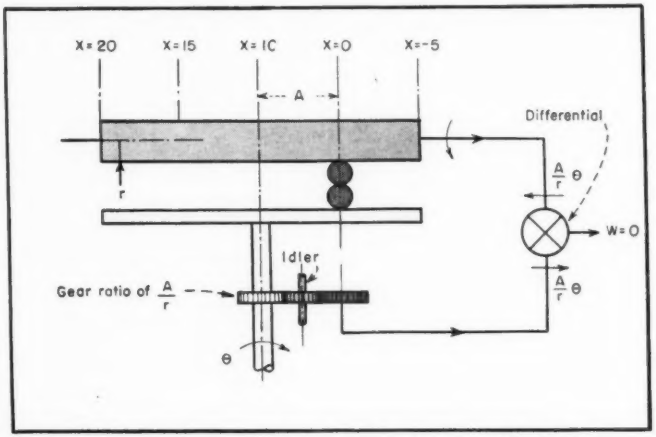


Fig. 12—Schematic representation of a zero offset mechanism for ball-disk integrators. There is less tendency toward pitting in this design, but a loss of scale factor.

The value of $1/r$ is known as the integrator constant.

The disadvantage of the two-disk integrator is that the output torque is limited by the frictional force developed between the two disks. But, the force required to change the second variable y, is directly proportional to the frictional force between disks. The two requirements for good operation are opposed.

This objection may be alleviated in part by using the ball-disk integrator shown in Fig. 11(B). Replacing disk B by two balls (B) and a cylindrical roller (C) produces rolling action radially across the disk, though the basic principle remains the same. Larger output torque may be obtained by increasing the spring force between roller, balls, and disk, with consideration given to a large radius thrust bearing to prevent cocking action of disk A. Note that con-

tinued operation at zero radius (y equals 0) will result in pitting disk A at the center. By using a differential the pitting can be partially avoided.

Fig. 12 shows a method whereby the point x equals 0 has been displaced a distance, A, from the centerline of the disk. With this method, the balls are rolling when the variable x is equal to zero, and there is less tendency toward pitting. However, with this method the range of $+x$ and $-x$ are not equal. As seen from this figure, x may vary from -5 to $+20$ units. There is also a loss of scale factor through the differential.

By using the equation

$$d(xy) = x\,dy + y\,dx$$

or

$$xy = \int x\,dy + \int y\,dx$$

multiplication may be performed by using two integrators. Fig. 13 shows that the variables x and y must be fed to each integrator subsequent to which the output of both integrators is fed into a differential. The output of the differential is the desired product.

Differentiation

The general problem of differentiating one variable with respect to another is solved by reversing an integrator, but unfortunately this does not yield a theoretically exact solution. The method requires an additional mechanical differential. The mechanism is shown in Fig. 14. The required derivative is

$$\frac{dy}{dx} = w$$

where w is the position of the ball carriage, x is the angular input to the disk, and y is the second input driving one side of the differential. The other side of the differential is driven by the output of the integrator, $\int w\,dx$. The spider of the differential is made to drive the ball carriage, either mechanically or through a servo system, so that $w = k\,(y - \int w\,dx)$ where k is the scale of w in terms of the inputs to the differential.

Rearranging

$$y - \frac{1}{k}\,w = \int w\,dx$$

and differentiating with respect to x,

$$\frac{dy}{dx} - \frac{1}{k}\,\frac{dw}{dx} = w$$

The error function of this differentiation may be expressed as

$$e = -\frac{1}{k}\,\frac{dw}{dx}$$

This inherent error, a time function, will disappear only when dw/dx equals 0 or when the carriage does not move as x is changed, implying dy/dx equals 1.

Theoretically dy/dx equals 1 will occur only after an infinite time. But it is possible to go in the direction of decreasing error by increasing k, that is, by causing w to move rapidly for small changes of y. Generally the increasing of k is accomplished by a servo follow-up in the w link of the differentiator. Increasing the speed of response too greatly, however, may cause undesirable oscillation of the system.

The preceding mechanism is the general form of differentiator, solving the general equation

$$w = \frac{dy}{dx}$$

In many cases encountered in computer design it is necessary only to find

$$w = \frac{dy}{dt}$$

that is, to differentiate with respect to time. This may be accomplished with a great deal less mechanism, since it amounts to building an accurate tachometer. The input to the device, y, is a shaft rotation, hence dy/dt is the speed of shaft rotation.

The mechanism of Fig. 15 is a force-balance servo system making use of the principle that viscous drag forces are proportional to velocity. The input quantity (y) drives a serrated drum closely fitted inside a housing, the housing being restrained from rotation by a spring. A viscous fluid is contained in the small clearance between housing and the drum,

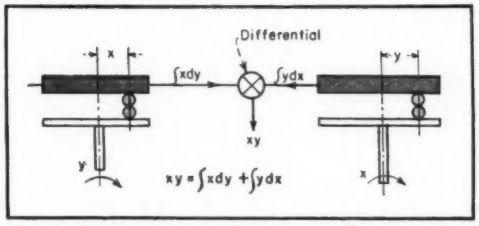


Fig. 13—Showing how two integrators can be combined for multiplication. Differential output represents the product.

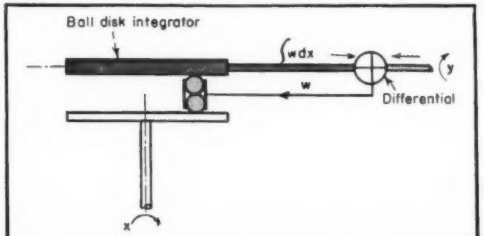


Fig. 14—Differentiating can be done by driving a ball-disk integrator in reverse. An additional differential is required for theoretical accuracy, driving mechanically or through a servo.

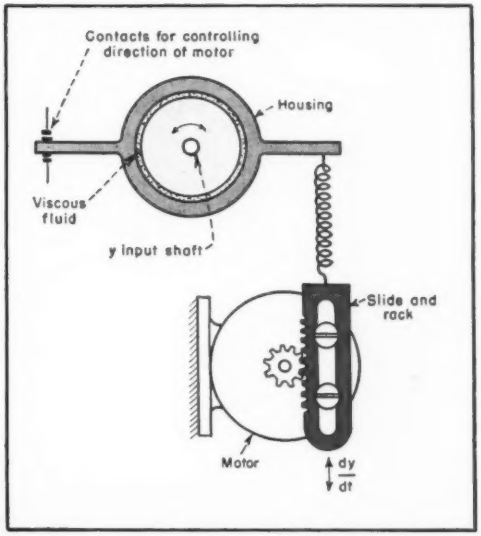


Fig. 15—Viscous drag differentiator has the advantage of sensitivity to slow rates. But, it may have several undesirable conditions, such as friction, hunting, or temperature effects.

and transmits a viscous drag torque to the housing which is proportional to the drum velocity. The arm connected to the housing is captured between electrical contacts; one end of the spring is attached to this arm, which in effect remains stationary. The spring length is regulated by a servo motor controlled by the capturing contacts. Any change in drum velocity causes the viscous torque to change; and contact is made in the correct sense to cause the motor to adjust the spring length and balance the system.

In this manner a measure of the input shaft velocity is obtained as a position, either of the servo-motor shaft, or of the end of the spring itself. The spring rate should be adjustable permitting accurate scale factor adjustments between input shaft velocity and output shaft position.

The great advantage of this differentiating system is its sensitivity to slow rates. With a fluid of high viscosity, small changes in rate of rotation cause high torque responses in the system. The rates of rotation normally involved in mechanical computation are generally quite slow, particularly if the quantity to be differentiated is the output of another computer unit.

Several undesirable conditions may occur in connection with this system:

1. Friction—Non-viscous friction in the drag unit which is independent of velocity of rotation will induce errors in the mechanism; it may be minimized by antifriction bearings. Its effect is to offset the torque-velocity curve by the amount of the friction torque. This effect becomes less serious as the viscous torque develops and is increased so that the friction force is a smaller percentage.

2. Hunting—This condition of rapid non-decaying oscillation may be found to some degree in any force-balance servo. It may be corrected or minimized by some form of damping, either friction, viscous or eddy current types.

3. Temperature Effects—The entire calibration of the viscous drag differentiator is dependent on a constant viscosity of the fluid. Since viscosity of the usual fluids is greatly affected by temperature changes, it is generally necessary to provide a means for regulating the ambient temperature of the device. Since commercial heater-thermostat combinations may give accuracies of ±5-10 F, a differentiator of high accuracy may be further compensated within this range by making the housing of low thermal-expansion metal such as invar, and the drum of aluminum. Then as temperature rises viscosity drops, lowering resultant torque; but at the same time the expansion of the aluminum drum decreases the fluid gap, thereby increasing the torque to its original value. This type of compensation requires careful matching of temperature-viscosity and thermal expansion curves, both non-linear, and is therefore valid only over such short ranges as indicated above.

Eddy-Current Differentiator

A device may be designed in which eddy-currents produce a drag proportional to velocity of rotation, for example, the automobile speedometer. In one design a powerful stationary permanent magnet is surrounded by a rotating cup of a non-magnetic current-conducting material, such as aluminum or copper. As the conducting material cuts the lines of flux, eddy currents are set up in direct proportion to the rate of cutting, producing a drag torque linear with speed.

The great disadvantage of this system is that the high velocity required to produce torque, even with very powerful magnets, necessitates high gear ratios, with associated power loss. The advantage of eddy-current drag is its relatively low variation with temperature, and in a unit which presents acute temperature-regulation problems, its use is often justified.

Approximate Linkages

For completeness, another method of mechanical computation will be described briefly. (See "Computing Mechanisms and Linkages," by A. Svoboda, McGraw-Hill, 1948). The method may be termed approximate linkages, and consists of links which are pivoted to each other and to a base plate or made fast to a shaft, as in Fig. 16. The method is approximate, and tedious accurate drafting layout work is required to determine the length of links, the angle through which the links operate, and that there will be no self-locking conditions. The method can be used to perform an approximate mechanization of an equation, or tabular data, that is, where the variables are related by a table showing particular values of each variable and the result. The linkages have class B errors, which may be determined by accurate layout. Class A errors are those arising from play in the pivots, bending of the links when they are transmitting load, inaccuracies in link length, and improper setting of the angle through which the links operate.

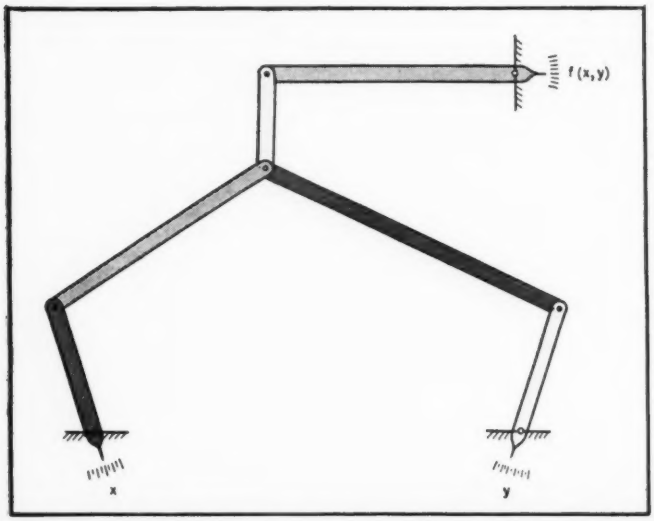
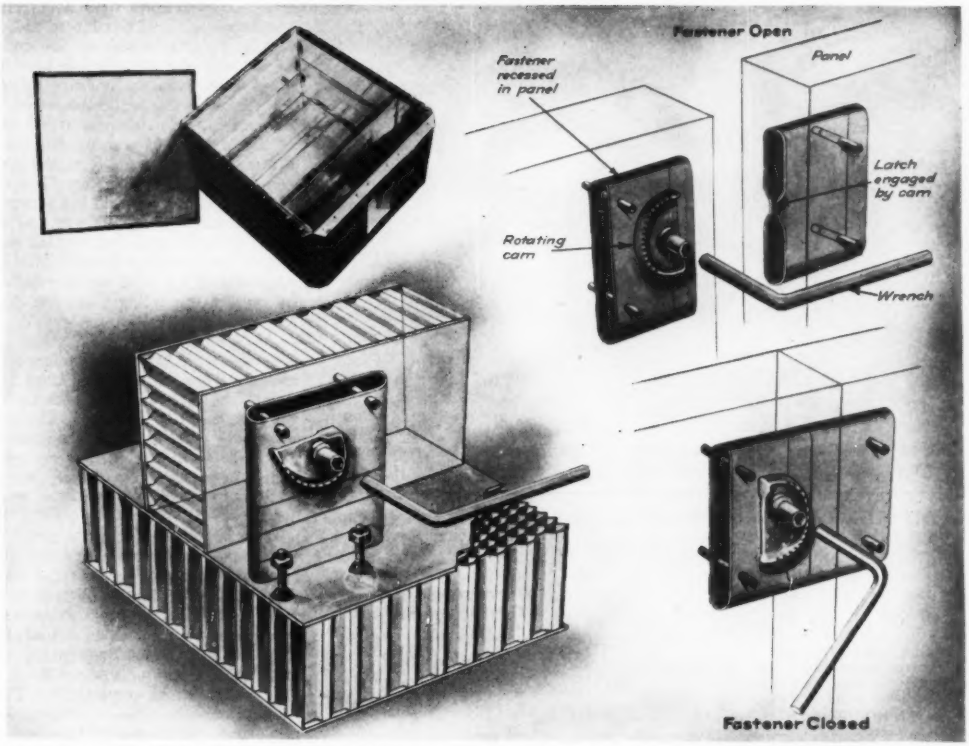


Fig. 16—Approximate linkages are another method of mechanical computation. Tedious, accurate layout work is required to minimize Class B errors.

EDITOR'S NOTE: Final article of this series will present, next month, several examples to show the principles used in combining components to form a computer. Final considerations, such as stops, electrical components, and vibration effects will be discussed. Two previous articles covered design planning and mechanisms for operations of algebra and trigonometry.



NEW STRUCTURAL USES for honeycomb panels are suggested by this locking construction developed by the United States Plywood Corporation. The knock-down box holds 1 ton per sq ft of internal pressure for about three months, suggesting use for long distance shipping of perishables. Two-in. honeycomb wall saves many pounds of conventional materials that would be required to withstand large pressures. Other suggested uses are portable walk-in refrigerators and pre-fabricated building parts.

Honeycomb-Sandwich Structures—II

Environmental conditions affect the physical properties of metal and fabric core honeycomb-sandwich panels. These structures also have acoustical and heat insulation properties that show promise for engineering application. Design analysis of honeycomb structures in aircraft give clues to their widespread use.

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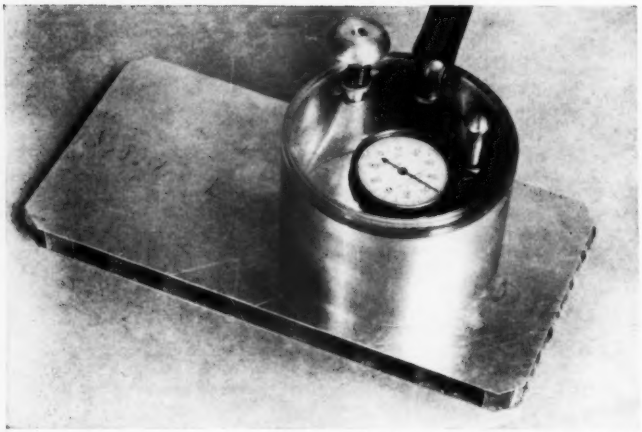
The Glenn L. Martin Company

MECHANICAL PROPERTIES of honeycomb-sandwich structures (see part I, page 81, August 1949 PRODUCT ENGINEERING) are affected by environmental conditions as well as strength and loading factors. In addition to their effect on mechanical properties, they are important in themselves, since honeycomb-sandwich structures are often applied for non-mechanical properties, such as heat insulation and sound-deadening.

Effects of Environment

Accelerated weather tests have been run on groups of samples having resin impregnated cotton fabric core one in. thick, one group faced with 0.016 in. and the other with 0.035 in. 24S-T aluminum. Although in use the edges are sealed off, in the test the panel edges were exposed. The weathering cycle consisted of 16 hr exposure in air at 100 percent relative humidity and a temperature of 120 F, 4 hr at an air temperature of —50 F, followed by 4 hr at an air temperature of 160 F. This cycle was continued for 12 weeks; at the end of each week, samples from each group were subjected to column compression tests. The specimens were unaffected. Another set of specimens for both groups were removed each week during this period and subjected to a static load applied to the center of the specimen while spanning 20 in. supports. There was no change in the stiffness of the specimens when tested at the end of each cycle.

Water immersion tests at room temperature of a group of ½ in. thick un-



American Instrument Company, Silver Spring, Md.

Fig. 11—"Bondimeter," vacuum type instrument used in detecting unbonded areas of facing to core. Indicator shows considerable deflection for a poor bond.

Table III—Moisture Resistance of Phenolic—Fabric Core Sandwich Panel

(0.016 in. 24ST Alclad Faces)

Condition of Specimen	Shear Strength of Core, psi	Toughness ratio of face to core bond	Shearing Modulus of Core, psi
Original state (dry)	174	39:1	10,500
Immersed in water for 3 days and tested wet	132	39:1	6,800
Immersed in water for 7 days and tested wet	122	43:1	6,700
Immersed in water for 7 days, then dried back to original state	154	25:1	10,100

Note: All failures in flexure test were in the core, none in the adhesive.

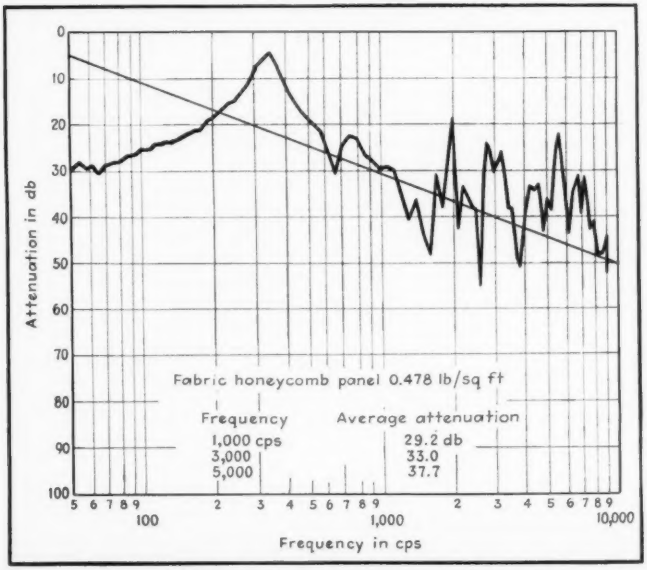


Fig. 12—Sound transmission through a fabric honeycomb-aluminum face sandwich panel. Aircraft soundproofing is concerned with low frequencies (up to 250 cps).

sealed cotton fabric-type honeycomb specimens faced with 0.016 in. 24S-T aluminum, give an idea of the ability of the core and the adhesive to withstand severe humidity conditions. Table III shows results of bending tests at the end of three days and at the end of seven days. As shown, these tests determine shear strength of the core and its modulus of rigidity. The effects of this treatment on the adhesive were investigated by a peel test in which a tensile load was applied normal to the specimen surface; relative toughness of the bond was determined by pulling the facing from the core and measuring the loads.

A special instrument, called a "Bondimeter", has been developed to measure the strength of the bond between face sheet and core. Shown in Fig. 11, the dial indicator will show practically nothing for a good bond, but will immediately show a large deflection over an unbonded section.

Heat Insulation and Acoustical Properties

Thermal conductivity of 4 oz cotton fabric honeycomb cores faced with 0.016 in. 24S-T aluminum has been tested on a special apparatus designed by the National Bureau of Standards. These tests, on panels $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{3}{8}$ in. thick, gave results of 0.85, 0.75, and 0.70 "K" factors respectively. The "K" factor is in terms of Btu per hr per deg F temperature difference for a specimen 1 ft square and 1 in. thick. These insulating values are approximately that of pine lumber. However, they can be materially improved by filling the honeycomb cells with foamed urea-formaldehyde; additional tests on such filled panels, $\frac{3}{4}$ and $\frac{1}{2}$ in. thick, yielded "K" factors of 0.45 and 0.55 respectively.

Sound transmission properties through fabric honeycomb core aluminum-faced structures, show interesting possibilities in the field of acoustics, because at low frequencies the panel has considerably greater attenuation than does an aluminum alloy panel of equal weight. However, at higher frequencies the plastic panel gives less attenuation. The lower frequencies, up to approximately 250 cps, generally offer the greater soundproofing problems in aircraft. Fig. 12 shows sound transmission through a fabric core sandwich panel.

Design Factors

In most commercial honeycomb-sandwich applications, the chief requirements, in addition to lightweight, serviceability and low cost, are that the sandwich structure be capable of carrying the designed loads with a min-

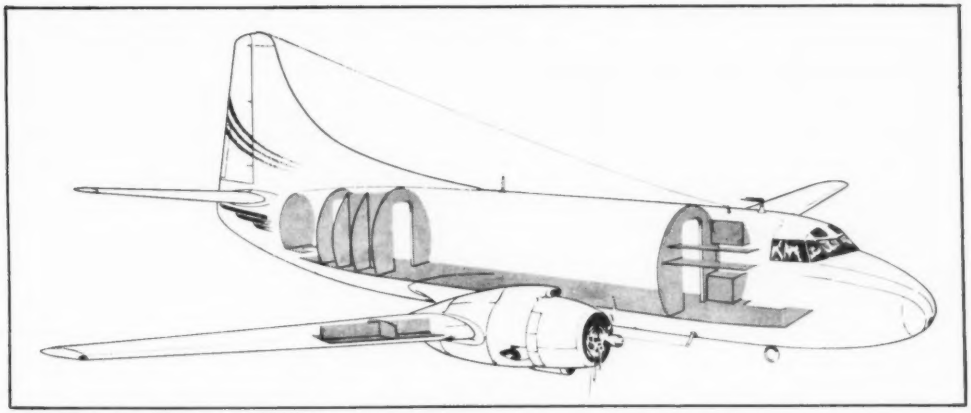


Fig. 13—Applications of honeycomb core sandwich materials are shown in Martin 202 36-passenger commercial transport.

imum deflection. In aircraft design these factors are particularly important, and the honeycomb core structures are used in such aircraft parts as floors, partitions, many secondary structures, and certain primary structures such as control surfaces and stabilizers. Honeycomb sandwich construction in the Martin 202 airplane is shown in Fig. 13. For these applications, a fabric base honeycomb core impregnated with a phenolic type resin has been used. The phenolic type resins have greater resistance to water absorption, high humidity, and have better elevated temperature behavior than the polyester type resins.

Because of the low density of the core and the thin face sheets, it is usually necessary to locally reinforce the core and improve the bearing area of the sandwich at points where structural attachments are to be made. High density inserts and edge banding molded into the panels are usually desirable. Banding materials commonly used are wood, plastics, aluminum extrusions and solid aluminum. Edging is also used between the panel faces for appearance and to provide a stop while molding, to determine the size of the finished panel. Most commonly used edging materials are plywood set on edge (aircraft grade birch face poplar core AN-P-69), phenolic fibers and extruded or bent-up aluminum sections. The width is determined by design requirements.

Inserts

Inserts are usually either plywood set on edge, phenolic fiber, or metal. Metal inserts are recommended wherever possible. Two types of metal inserts are shown in Fig. 14; Type I is used when attaching parts to the panel, and Type II is used to attach the panel to the structure.

Sawing of cores and sandwich assemblies is done with fine tooth metal cutting blades having 18 to 24 teeth per in. Sanding of cores and sandwich assemblies is generally done with metal cutting abrasive sanding belts or disks.

Attachments

Typical methods of attachment of sheets, using inserts, doublers or spacers, are shown in Fig. 15. Spacer bushings made of an aluminum alloy have been designed for use on panels where attachment points cannot be predetermined. These are general-purpose fittings which can be inserted at any point in the panel and will transfer loads in the plane of the plate as well as normal to the plate.

Floor panels of the 202 Transport are $\frac{3}{4}$ in. thick; face plates are 24S-T aluminum, and the core is phenolic-impregnated cloth, of $\frac{7}{16}$ in. cell size. The allowable column stress of this flooring, approximately 33,000 psi, is used as the maximum ultimate design stress. A major problem was to design a satisfactory transverse splice for this axial load, with a permanent set value sufficient for use in a composite riveted structure. The final suc-

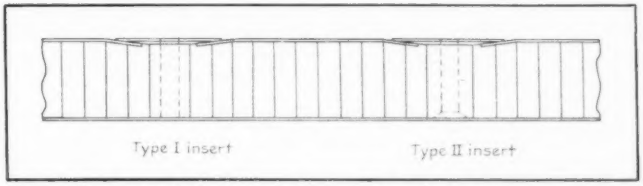


Fig. 14—Two types of aluminum inserts used in sandwich panels; Type I insert is used when attaching parts to the panel; type II insert attaches panel to structure.

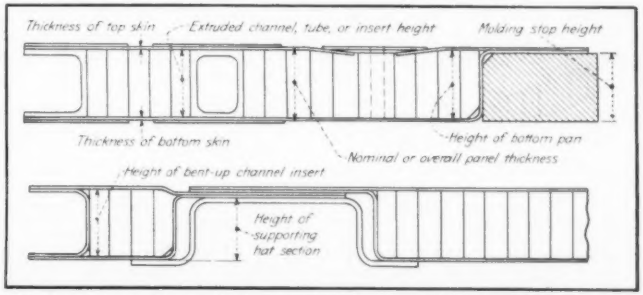

Thickness of top skin
Extruded channel, tube, or insert height
Molding stop height
Thickness of bottom skin
Height of bottom pan
Nominal or overall panel thickness
Height of bent-up channel insert
Height of supporting hat section

Fig. 15—Edging and insert details in sandwich-constructed aircraft flooring.

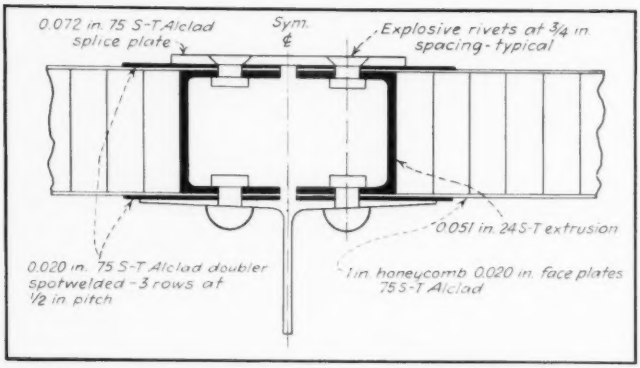

0.072 in. 75 S-T Alclad splice plate
Sym. ℄
Explosive rivets at 3/4 in. spacing - typical
0.051 in. 24S-T extrusion
0.020 in. 75 S-T Alclad doubler spotwelded - 3 rows at 1/2 in. pitch
1 in. honeycomb 0.020 in. face plates 75 S-T Alclad

Fig. 16—Transverse splice of two sandwich panels, designed for axial loads.

cessful design is shown in Fig. 16. This joint tests to an ultimate value of approximately 30,000 psi in 0.020 in. face plates, with a total permanent set of 0.030 in. It should be noted that the transfer of shear in the honeycomb core is accomplished by allowing the core to bear on the lower splice tee, and no reliance is placed on the glue bond between the end wood edge and the core.

Honeycomb flooring enables a weight saving of approximately 60 lb, compared with other types of floor construction; most of this is in insulation that would have been required in the design. The flooring is stiffer, smoother, and has a much better "feel" than conventional aircraft flooring.

Detailed design of joints and connection require special care, so that loads or eccentricities that tend to break the glue bond between face and core are not induced.

Other applications of honeycomb construction to aircraft include the wing center rib of the Martin 202. This rib acts as a support for the ends of beams separating the cell gas tanks. It also transfers crushing loads applied to it by top and bottom wing covering. The rib is 1 in. thick and made of phenolic impregnated cloth of $\frac{7}{16}$ in. cell size and face sheets of 0.012 and 0.025 in. 24S-T aluminum; ultimate sheer stress design is 20,000 psi for the 0.012 in. face plates. Partitions and doors are made of honeycomb construction; panels are $\frac{1}{2}$ in. thick with standard core and are covered with 0.012 in. 24S-T aluminum face plates. These are secondary structures designed only to carry items of auxiliary equipment mounted on them.

Honeycomb core construction is being used in wings for pilotless aircraft; face plates on the wing are of 0.051 in. 24S-T aluminum alloy with an ultimate design stress of 50,000 psi. The core is phenolic impregnated cloth $\frac{7}{16}$ in. cell size; core weight represents 13 percent of the total wing weight, considered low for this type of structure.

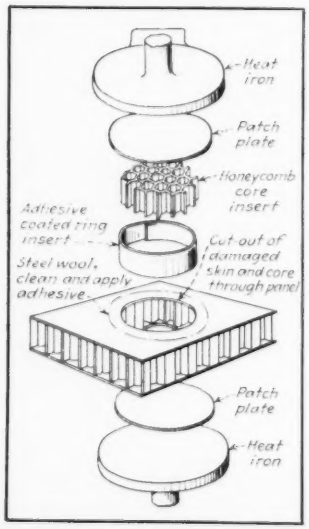


Fig. 17—Honeycomb panel can be readily repaired with specially prepared core inserts. Materials are available in kit form.

Repair of Sandwich Panels

The ability of the honeycomb-aluminum face sandwich to withstand load concentrated on small areas is important on aircraft flooring applications. Where local surface damage does occur, it can easily be repaired by using specially prepared patch plates of various sizes.

For small holes and slits the repair is made by simply bonding on a beveled edge plate over the damage. Larger dented areas are fixed by filling the cavity with a synthetic compound that is cured and shaved flush with the surface of the panel. A patch plate is then bonded over the damage, which is stabilized by the inserted filler. Large damaged sections sometimes necessitate replacement of the core, as shown in Fig. 17. In making repairs the thickness of the patch plate is usually equal to the thickness of the sandwich facing. FM-45 adhesive is used for making all bonds and is cured at 300 F for 20 min under 10 psi pressure.

AUTHORS' NOTE: We are indebted to the work of W. W. Troxell, formerly Chief, Engineering Laboratories of The Glenn L. Martin Company and now deceased, for a great deal of the basic studies which have served as source material for this article.

* * * *

THE SCIENCE OF METALLURGY actually began when Sorby, a British scientist, reported in 1864 the results of his investigations on the use of the microscope to study the physical structure of meteoric iron. This was followed by studies in the same general field by Martens, in Germany, about 1878. The work of these two scientists, however, aroused little interest at the time, and nothing further was accomplished until Sorby showed some photomicrographs of iron and steel to the British Iron and Steel Institute in 1886. After this, the importance of metallurgy grew steadily.

* * * *

THE ORIGINS OF MODERN METAL PLATING techniques go back before the time of Christ, but one of the most unusual cases of metal plating for unlawful profit is found in Spanish history. When the early Spaniards brought platinum back from the New World, the Spanish metallurgists were unable to melt the metal. The wily Spaniards, in order to use this metal, hammered slugs of it, plated these slugs with gold or silver, and so made counterfeit coins! Eventually, the Spanish government had to pass a law banning the importation of this dangerous and "worthless" metal.

Involute Curve Calculations

Comparison of the numerical operations required and of the accuracy obtained in the use of two methods for calculating the coordinates of points on layouts of involute curves. In the first method one variable angle is used; and in the second method, three angles are employed.

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The Gleason Works

THE PURPOSE AND SCOPE of the method of laying out an involute curve that was presented by the author in the short article "Formulas for Involute Curve Layouts", PRODUCT ENGINEERING, August 1948, p 145, was intended to be completely general and applicable to any chosen part of any involute curve for a gear tooth, cam, templet, or gage.

In a second article by Michael Vasvari, "Involute Curve Layouts," PRODUCT ENGINEERING, January 1949, p 128, equations are recommended for the involute curve on a gear tooth of standard pressure angle.

DIAGRAMS. Diagrams from the two articles are reproduced here as Figs. 1 and 2, to illustrate the linear and angular values that appear in the various equations. The comparative simplicity of Fig. 1 is obvious.

EQUATIONS FOR GENERAL PROBLEM. In the first article the following equations were presented:

$$x = \rho \sin\theta \pm b\,(\theta \sin\theta - \text{vers}\,\theta) \quad \text{(A)}$$

$$y = \rho\,\text{vers}\,\theta \pm b\,(\sin\theta - \theta\cos\theta) \quad \text{(B)}$$

Having decided on the dimensions b and ρ, the procedure is to select or assume values of a single variable angle θ, and then to calculate the coordinate distances x and y for points on the curve.

In the second article the x- and y-coordinates are obtained by a number of steps indicated in the following equations:

$$\text{arc}\,\beta = \tan\alpha - \text{inv}\,\alpha_P \quad (1)$$

$$R_P = b/\cos\alpha_P \quad (2)$$

$$x = R_P\cos\beta - b \quad (3)$$

$$y = \rho - R_P\sin\beta \quad (4)$$

in this case, b and ρ are given as before, and values of the variable angle α_P are assumed or selected. An unknown angle β has to be determined.

COMPARISON OF METHODS. In the first method the various values of θ are chosen so that all trigonometric functions are taken directly from tables without interpolation. In contrast to this, the second method uses three angles, namely: a constant angle α, an assumed or chosen variable angle α_P, and a dependent angle β for which interpolations are required in order to obtain its sine and cosine.

In comparing the work of calculation by the two methods, it is proper to consider not only the numerical operations—addition, subtraction, multiplication, and division—but also the number of values that are read from tables, as these too require time and attention. A careful count of such operations for the two methods yields the following results:

Method	Equations	Values from Tables	Numerical Operations
First	(A) (B)	2	11
Second	(1) (2) (3) (4)	9	12

This count includes the interpolations required in the second method, but does not indicate the bothersome care that must be taken to avoid mistakes in such work.

EQUATIONS FOR STANDARD GEARS. In the second article, equations are presented in a form applicable directly to the involute curve of a standard gear tooth. The starting information is the pitch radius r and the standard pressure angle α. The same thing can be done by the general method of the first article; and the two sets of equations are

First Method

$$x = r\,[\sin\phi\sin\theta \pm \cos\phi\,(\theta\sin\theta - \text{vers}\,\theta)] \quad \text{(A1)}$$

$$y = r\,[\sin\phi\,\text{vers}\,\theta \pm \cos\phi\,(\sin\theta - \theta\cos\theta)] \quad \text{(B1)}$$

Second Method

$$x = r\left(\frac{\cos\alpha}{\cos\alpha_P}\cos\beta - \cos\alpha\right) \quad (7)$$

$$y = r\left(\sin\alpha - \frac{\cos\alpha}{\cos\alpha_P}\sin\beta\right) \quad (8)$$

Equations (A1) and (B1) were not in the first article, as the intention there was to present the completely general case. These new equations, however, have the same inherent advantages as Eqs (A) and (B).

The values of the two brackets in Eqs (A1) and (B1) may be designated as "constants" C_A and C_B, in the same way as in the second article

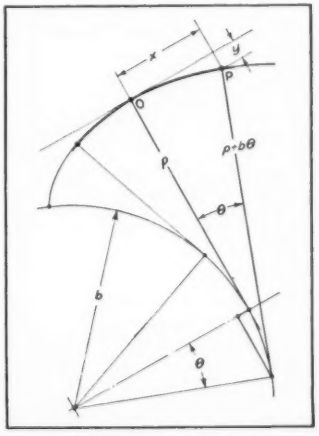

Fig. 1—Diagram presented in first article for deriving equations for coordinates of points on the involute of a circle.

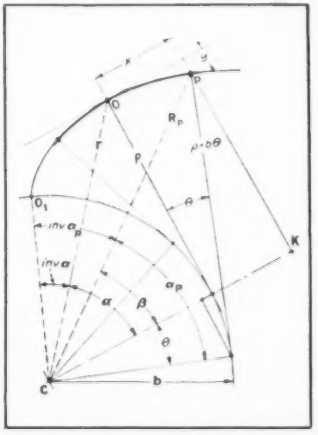

Fig. 2—Diagram presented in second article for deriving equations for coordinates of points on involute gear tooth.

the values of the parentheses in Eqs (7) and (8) are designated as C_1 and C_2. In that article it was proposed to compile tables of these values based on a standard pressure angle α and a varying angle α_P. Tables for C_A and C_B would be based on a standard pressure angle ϕ and a varying angle θ.

A count of the operations required to obtain a C-value by the two methods results as follows

Method	Constants	Values from Tables	Numerical Operations
First	(C_A) (C_B)	5	11
Second	(C_1) (C_2)	11	12

These figures indicate the work needed for a single determination for θ or α_P in one direction from the O-point. To obtain the value for the same angular change in the opposite direction, it is only necessary in the first method to apply the minus sign instead of the plus sign in Eqs (A1) and (B1), which requires only two additional numerical operations. The second method, by contrast, would require nine new values read from trigonometric tables and twelve new numerical operations. The comparison is thus overwhelmingly in favor of Eqs (A1) and (B1).

After the C-constants are available in tables, they would be used in the same way by both methods.

SMALL ANGLES VERSUS LARGE ANGLES. The main purpose of the present article is to show how one way of handling calculations may be easier, quicker, and inherently less subject to inaccuracy than another. The writers of the two articles have different opinions as to whether small or large angles are favorable to accuracy.

It is stated for instance in the second article that "the trigonometric functions of small angles are not sufficiently exact for such calculations." It is a matter of fact, however, that in the compilation of trigonometric tables the infinite series by which the sine and tangent functions may be determined converge rapidly for small angles but not for large angles. This fact makes the determinations for small angles comparatively easy. Therefore, the statement may have been made with the cosine in mind, because it approaches unity as the angle decreases. Since in the method of the first article, the cosine of θ need not be used, the intended criticism does not apply. If this statement appears to be contradicted by the presence of cos θ in Eqs (B) and (B1), it is replied that, if one wishes, the term

$$(\sin\theta - \theta\cos\theta)$$

may be written as

$$[\theta \operatorname{vers}\theta - (\theta - \sin\theta)]$$

which eliminates the cosine. As θ decreases in size, the value of this bracket converges toward $\theta^3/3$. The value of the parenthesis in Eqs (A) and (A1) converges toward $\theta^3/2$ in a similar way.

The superiority of the treatment of angles in the first method will be appreciated by anyone who cares to make comparative calculations, for instance, by Eq (B1) and Eq (8), say for the case of a 100-tooth gear for which the first point on the curve might be calculated with θ equal to 0.5 deg or with α_P equal to α plus 0.5 degree.

ERRORS IN ANGLES. The second article mentions the "possibility of mistakes caused by table differences." Since "table differences" must be used in the second method, the advantage is with the first method, in which they are not used.

Furthermore, in the first method, there can be no error in angle, even by as much as "one second," because the only angles used in the calculations are chosen and not calculated. In determining the dependent angle β, that kind of difficulty does occur in the second method.

It is suggested that there may have been an error in the example of the first article, because ρ/b did not exactly equal tan 20 deg, and that this demonstrates the likelihood of error by the first method. Such an error, even if it had occurred, would not have been an error in method but only in the values assumed in an example. Actually, however, the example was of a case where ρ/b was not exactly equal to tan 20 deg. The suggestion was not well considered.

BASIC DIMENSIONS FOR GENERAL CASE. The radius b of the base circle and the radius of curvature ρ are fundamental linear dimensions from which to determine: (1) An involute curve, and (2) the position of a selected point on it. These values are particularly suitable for the general case; and although they are not used in routine gear cutting, they are quite likely to be known when an exact layout is to be made.

CONCLUSION. The beautiful simplicity of the involute of the circle is clearly apparent in Fig. 1, in which only essential lines and arcs are shown. In determining points on a layout of the curve of any size whatever and based at any chosen position, the use of only the one variable angle θ leads to the best, easiest, and quickest method of calculation.

* * * *

THE ANCIENTS HAD A GOOD KNOWLEDGE of the uses for various quenching media for imparting different properties to steel, but they seldom used anything as prosaic as plain water or clean oil. For instance, here are the instructions for imparting a wonderful temper to a Damascus sword blade: "Let the high dignitary furnish a slave of good frame, let him be bound down, shoulders upwards before a statute of the god Bal-Hal. Then let the master workman, having hammered the blade to a smooth and thin edge, thrust into the fire of his cedarwood coals, in and out, until the steel be the color of the rising sun when it comes up over the desert to the East, and then with a quick motion, let him pass the sword from the point to the hilt six times through the most fleshly portion of the slave's body until the metal has become the color of the purple of the king. Then, with one stroke let the masterworkman sever the head of the slave from his body, and if the sword displays no nick or crack along the edge, and the blade can be bent around the body of a man and not break, it will be accepted as a perfect weapon."

* * * *

BECAUSE LEAD IS SUCH AN INACTIVE METAL and because it can be worked so easily, it was one of the first metals to be used by ancient man. The floors of the Hanging Gardens of Babylon, which were 400 ft. square, were entirely lined with sheets of lead the edges of which were securely fastened together by soldering. These joints had to be water-tight. If the lead sheathing had leaked, the floor would not have been able to retain moisture for the luxuriant vegetation growing in the gardens. Still worse, leaky joints would have allowed water to seep down into the nobles' apartments. Knowing that they would be burned alive if the soldered joints did not hold, these early metalsmiths did a good job.

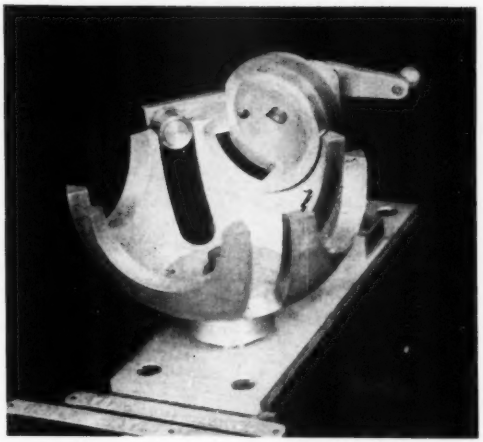

Fig. 1—A model of a spherical Geneva wheel mechanism for obtaining 180 deg motion—180 deg dwell of driven members.

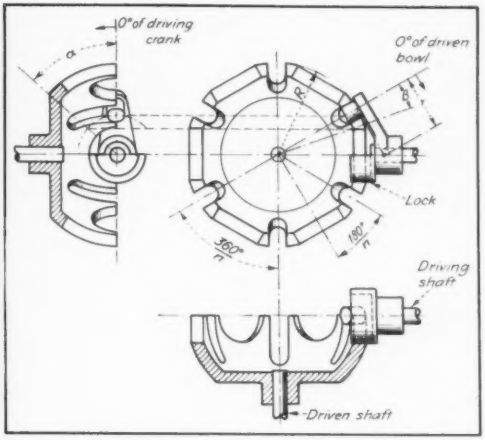

Fig. 2—Drawing of a six slot spherical Geneva wheel, indentifying the nomenclature used in the equations and the charts.

Kinematics Of Intermittent Mechanisms III—The Spherical Geneva Wheel

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A RARE, but useful member of the Geneva wheel group is the spherical Geneva. Where the external Geneva provides dwell periods greater than motion periods, and the internal Geneva provides the opposite, the spherical Geneva has a dwell period exactly equal to the motion period. Both motion and dwell periods occur over 180 deg of the driving shaft motion. In spite of its simplicity and of its smooth, shock free operation this device is hardly known to the mechanical engineer. The writer even applied for a patent on it, only to find that it was patented thirty years ago.

The spherical Geneva, Fig. 1, consists of a crank, attached to the driving shaft and carrying the driving roller, and the driven bowl, attached to the output shaft. Driving and driven shafts are not parallel as in the conventional Geneva drives, but at 90 deg to each other, with their axes intersecting. The bowl has the general shape of a hollow hemisphere, having slots along its meridian lines into which the driving roller fits.

The axis of the driving roller intersects the axis of the driving shaft at an angle determined by the number of slots on the bowl. While rotating, the drive roller axis describes the surface of a cone. The cone's apex lies in the intersection point of the axis of input shaft, output shaft and drive roller. This point is also the center of the hemispherical bowl.

Attached to the crank is the semicircular lock, fitting into semicircular cutouts on the bowl and working in much the same way as the conventional lock in the ordinary Genevas.

Motion period of this drive is always 180 deg of the cycle, independent of the number of slots, since the roller always engages and disengages on the equator of the bowl.

To determine the equations of motion the following notations (see Fig. 2) are used

R = outside radius of bowl
n = number of slots

With that position of the roller axis where the roller enters the slot established as the zero line, the crank radius is

$$r = R \tan \frac{180°}{n}$$

if r is measured tangentially to the bowl equator as Fig. 2 shows.

Calling

$$\tan \frac{180°}{n} = m$$

then

$$r = Rm \qquad (1)$$

It can easily be shown that

$$\frac{m - \tan \beta}{1 + m \tan \beta} = m \cos \alpha \qquad (2)$$

where α designates the angular position of the driving crank at any time, and β the corresponding angular displacement of the bowl. It follows from Eq (2) that

$$\tan \beta = m \left(\frac{1 - \cos \alpha}{1 + m^2 \cos \alpha} \right) \qquad (3)$$

from which the angular displacement β is found.

Differentiating Eq (3) the angular velocity of the bowl is

$$\frac{d\beta}{dt} = \omega \left(\frac{m \sin \alpha}{1 + m^2 \cos^2 \alpha} \right) \qquad (4)$$

where the constant angular velocity of the driving shaft, rotating at p revolutions per minute equals ω and

$$\omega = p\pi / 30 \qquad (5)$$

Differentiating Eq (4) the angular acceleration is found to be

$$\frac{d^2 \beta}{dt^2} = \omega^2 m \cos \alpha \left(\frac{1 + m^2 + m^2 \sin^2 \alpha}{(1 + m^2 \cos^2 \alpha)^2} \right) \qquad (6)$$

Maximum velocity occurs at α equals 90 deg and must equal ωm.

To find the maximum acceleration, differentiate Eq (6). Making this third derivative zero, the maximum

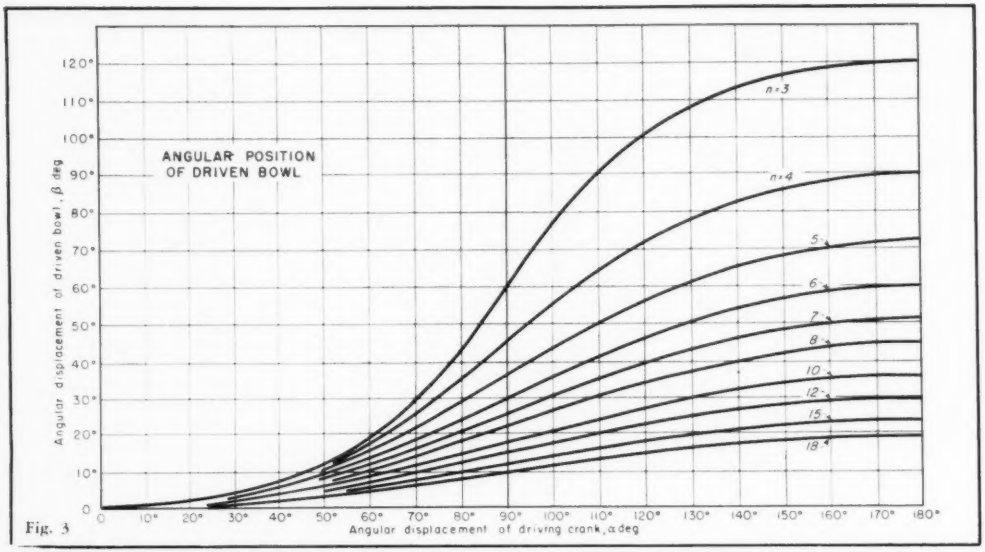

Fig. 3

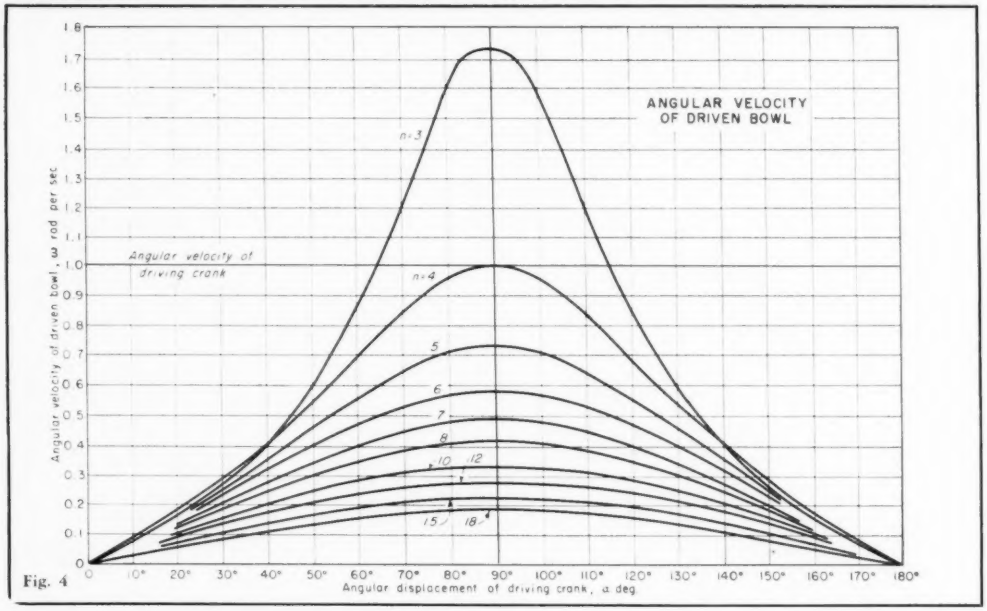

Fig. 4

acceleration is found to occur where

$$\cos\alpha = \frac{\sqrt{3+3m^2-\sqrt{9m^4+16m^2+8}}}{m} \quad (7)$$

It is obvious that Eq (7) will produce irrational values of α for certain values of m. A closer investigation shows that a rational extreme outside of α equals 0 exists only for 3, 4, 5, 6 and 7 slots. If there are more than 7 slots in the bowl, then the highest acceleration occurs at α equals 0, as can be seen from Fig. 5.

To find the value of the highest acceleration for each given number of slots, substitute α, found from Eq (7), into Eq (6), if the bowl contains less than 8 slots. If the bowl contains 8 or more slots, the maximum acceleration occurs at α equals 0 and this maximum acceleration will equal

$$\omega^2\left(\frac{m}{1+m^2}\right)$$

Table I shows the principal kinematic data for bowls with from 3 to 18 slots. Graphs in Figs. 3, 4 and 5 show respectively the angular displacement, velocity and acceleration.

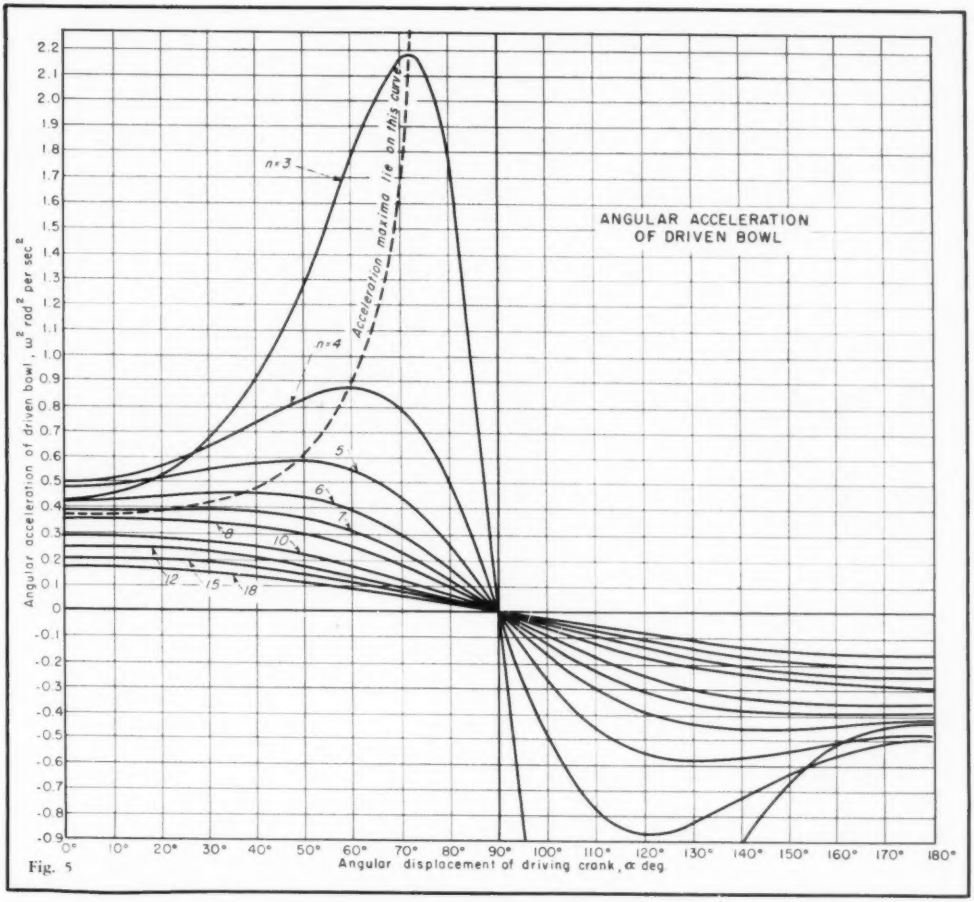

Fig. 5

Table I—Principal Kinematic Data for Spherical Geneva Wheels

Number of Slots, n	Angle through which bowl rotates in one cycle	$\frac{180°}{n}$	$\tan\frac{180}{n} = m$ and crank radius r for $R = 1$	Maximum angular velocity of driven bowl, rad per sec, equals ω multiplied by values tabulated			Acceleration of bowl when roller enters slot, rad² per sec² equals ω^2 multiplied by values tabulated. $\alpha = 0$	Maximum angular acceleration of driven bowl, rad² per sec², equals ω^2 multiplied by values tabulated		
				α	β	Multiplier		α	β	Multiplier
3	120°	60°	1.73205	90°	60°	1.732	0.434	72° 13′	32° 8′	2.17
4	90°	45°	1.00000	90°	45°	1.000	0.500	59° 40′	18° 12′	0.873
5	72°	36°	0.72654	90°	36°	0.727	0.475	48° 35′	10° 16′	0.582
6	60°	30°	0.57735	90°	30°	0.577	0.432	37° 28′	5° 23′	0.455
7	51° 25′ 43″	25° 42′ 52″	0.48162	90°	25° 43′	0.482	0.393	20° 42′	1° 28′	0.394
8	45°	22° 30′	0.41421	90°	22° 30′	0.414	0.354	0°	0°	0.354
9	40°	20°	0.36397	90°	20°	0.364	0.321	0°	0°	0.321
10	36°	18°	0.32492	90°	18°	0.325	0.294	0°	0°	0.294
11	32° 43′ 38″	16° 21′ 49″	0.29368	90°	16° 22′	0.294	0.271	0°	0°	0.271
12	30°	15°	0.26795	90°	15°	0.268	0.251	0°	0°	0.251
13	27° 41′ 32″	13° 50′ 46″	0.24655	90°	13° 51′	0.247	0.232	0°	0°	0.232
14	25° 42′ 52″	12° 51′ 26″	0.22842	90°	12° 51′	0.228	0.216	0°	0°	0.216
15	24°	12°	0.21256	90°	12°	0.213	0.204	0°	0°	0.204
16	22° 30′	11° 15′	0.19891	90°	11° 15′	0.199	0.192	0°	0°	0.192
17	21° 10′ 35″	10° 35′ 17″	0.18745	90°	10° 35′	0.187	0.181	0°	0°	0.181
18	20°	10°	0.17633	90°	10°	0.176	0.171	0°	0°	0.171

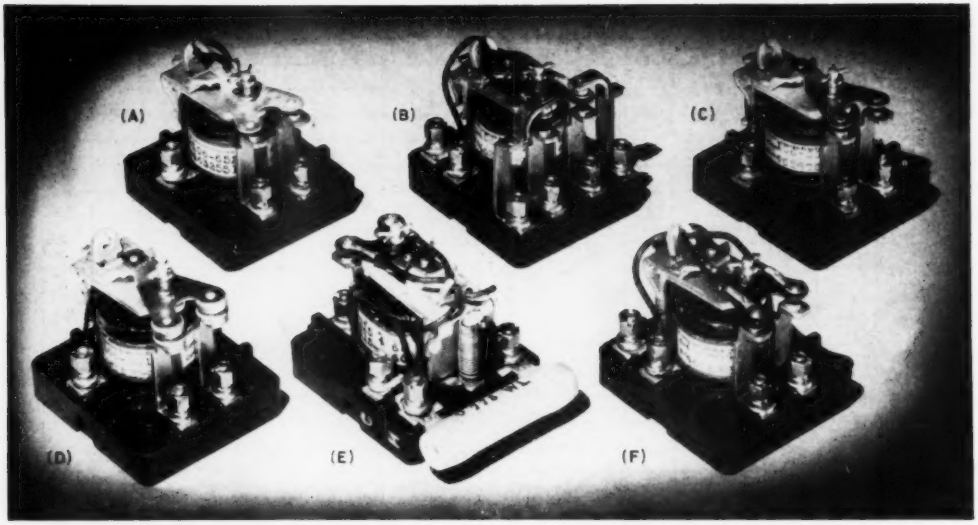

Fig. 1—Phenolic base midget relays: (A) single pole, with common feed; (B) double pole, double-throw; (C) single-pole, double-break; (D) single-pole, double-break; (E) single-pole, normally open for instrument control; (F) double-pole, normally open.

Magnetic Relays

Types and Characteristics

Magnetic relays for industrial control application, including heavy duty, midget, latching, and field control types. Second of two articles on construction and selection of standard relays.

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Application Engineer,
Ward Leonard Electric Co.

WHEN SELECTING industrial type magnetic relays, the logical method of approach is to (1) determine circuit requirements; (2) set-up basic performance specifications; and (3) pick the units, if possible, from standard types. The first of these steps was described in detail in an article by Mark Morgan on elementary wiring diagrams, which appeared in the July issue of PRODUCT ENGINEERING; the second step was covered somewhat in detail in the previous part of this article in the September number. Therefore, the following discussion will be limited to the description, applications, and limitations of low voltage magnetic relays, including (1) heavy duty; (2) midget; (3) miniature; (4) sensitive; (5) time delay; (6) field control; (7) series; and (8) special types of relays.

Heavy Duty Relays

Magnetic relays of the heavy duty type, Fig. 2, are comparable in both size and rating with the smaller size NEMA magnetic contactors. Most heavy duty industrial relays are constructed so that a wide variety of contact combinations can be obtained, with the various parts being mounted on molded phenolic insulating bases. Contact fingers are usually spring-backed, with flexible leads attached to screw type terminals. The contacts are generous in diameter and relatively thick to provide adequate material for wear allowance.

Some heavy duty relays may control as many as eight electrically independent circuits, or transfer up to four load circuits from one power source to another; others with more contacts are available as specials. Contacts can be furnished with or without magnetic blowouts, and with special contact materials. Standard coils for shunt connection are obtainable for operation up to and including 230 volts d-c and 440 volts a-c, 60 cycles. Special series coils for current operation, as well as those for non-standard voltages and frequencies, may also be obtained.

The industrial applications of heavy duty relays are numerous and varied. A primary use is for starting, stopping and reversing control of a-c and d-c motors on machine tools, woodworking machines, stokers, oil burners, and similar equipment. An equally important use is for pilot or control circuit operation on integral hp motor starters and controllers. In such applications, relay operation may depend on the functioning of control devices or accessories including magnetic contactors, pressure switches, limit switches, other magnetic relays, pushbuttons, and similar devices.

Heavy duty relays also are applied for control of tungsten lamp and resistive or infrared heating loads. When used with resistive heating loads, nominal contact ratings are permitted. For infrared heating or tungsten lamp loads, contact rat-

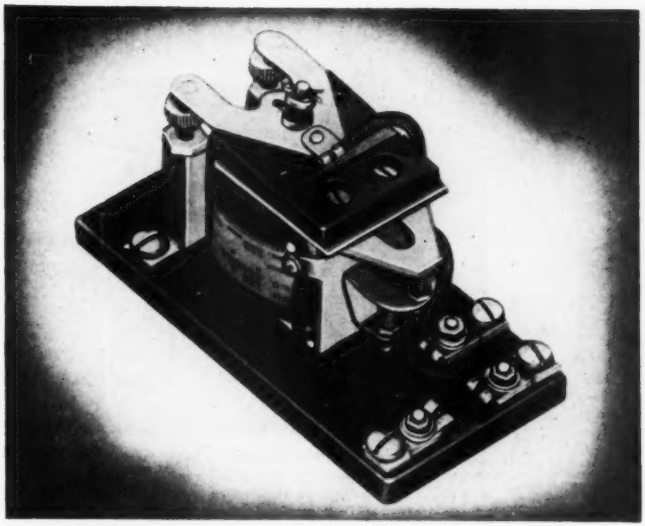


Fig. 2—Double-pole, heavy-duty relay, with common feed. Flexible leads, thick silver-to-silver contacts, and phenolic bases are common on this type.

ings must be reduced approximately 50 percent because of the heavy in-rush current caused by the low resistance of the lamps when cold, which would decrease contact life.

The max or peak inrush currents should also be known when heavy duty relays are used for switching capacitors, rectifiers, transformers and reactors. Many circuits involving these components yield high momentary current values in spite of the fact that the nominal circuit currents are low. Accurate data should also be obtained where inductive loads like solenoids or magnetic contactors must be interrupted, and especially when one relay circuit must handle several inductive loads simultaneously. The latter case should be avoided wherever possible by using relays of the multi-pole type.

Midget Relays

Industrial demands for magnetic relays more compact in size than heavy duty relays yet ruggedly built prompted development of midget type relays, such as shown in Figs. 1 and 3. Midget relays are intended primarily for low voltage use—115 to 230 volt max—when circuit loads are not in excess of 6 amp, although some types will, in single-pole combinations, handle 20 amp or more.

Midget magnetic relays have many of the same general features found in those of the heavy duty type. Ordinarily, some sort of knife edge or semi-knife edge bearing construction is used, and insulating bases or metal bases can be obtained. Metal base relays require no additional insulation between the bases and the control panel or mounting surface, and consequently their overall dimensions (depth and width) are somewhat less than those with insulating bases.

Contact combinations are usually limited to one, two or three poles, single or double-throw. Average coil consumption is usually not more than 2 watts d-c and 4 watts, 60 cycles. The majority of midget relays have screw post terminals for front connection, but some types are available with solder tab terminals.

Midget relays with somewhat high current carrying capacity are equipped with extra large silver contact buttons and increased contact gaps. As some types of the heavier duty midget relays are approved by the Underwriters as motor controllers, they are often applied for control of small motors driving pumps, compressors, fans and other small machines. Other control applications include alarm, heating and lighting systems; air-conditioning equipment; and aircraft apparatus.

One type of three-wire instrument control circuit using a midget magnetic relay is illustrated in Fig. 4. When the low thermostat circuit closes, in the first instant after the low thermostat circuit closes, current flows from L_2 to L, C, CR, and the resistor L_1. The relay coil becomes energized, thus closing contacts A and B to shunt out the thermostat and to complete the load circuit. If the low contact of the thermostat opens, the control circuit remains the

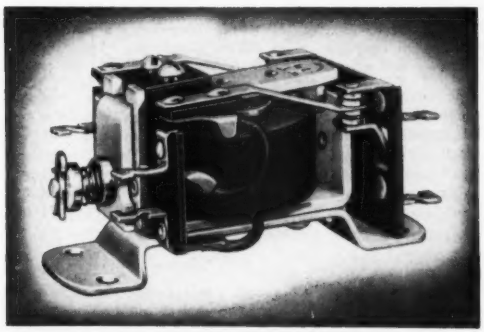


Fig. 3—Metal base midget relay. Advantage of the metal base is that the overall dimensions of the relay can be reduced.

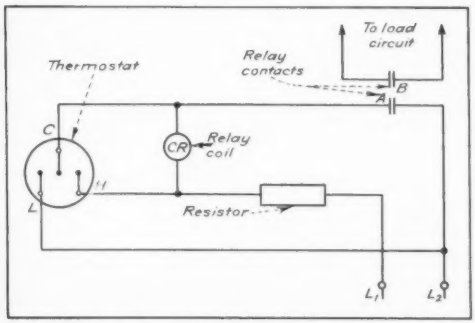
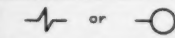
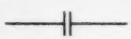
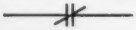
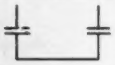
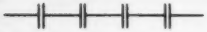
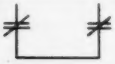
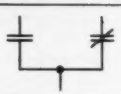
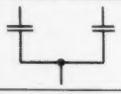
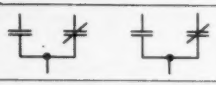


Fig. 4—Midget magnetic relay in a three-wire instrument control circuit. Current flow through the thermostat is only momentary.

Table I—Relay Symbols for Schematic or Elementary Diagrams

A.S.A.①	Description
COIL SYMBOLS	
	*Potential coil*
	Series coil
	Blowout coil
CONTACT SYMBOLS	
	*Normally-open, single-break*
	*Normally-closed, single-break*
	*Normally-open, double-break*
	*Normally-open, multi-break*
	*Normally-closed, double-break*
	*Double-throw transfer, single-break*
	*Normally-open, double-pole with common feed*
	Double-throw with isolated contacts; or single pole N.O., single pole N.C.
	*Double-pole, double-throw*

①Adopted from American Standard for Electric Power and Control, Z 32.3 1946

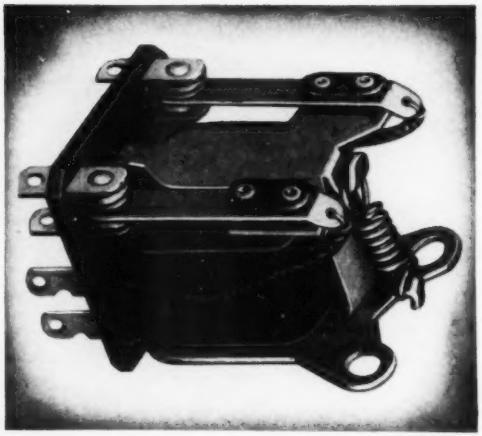


Fig. 5—Typical miniature magnetic relay for use when circuit current is below 2.0 amps and voltage is 115 maximum. The unit above has double-pole double-throw, silver to silver contacts.

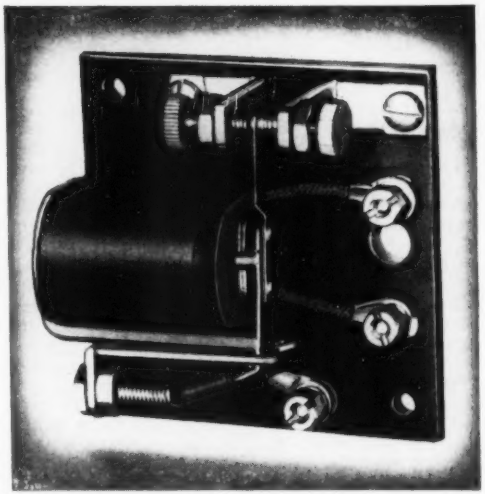


Fig. 6—Sensitive relay capable of operating on a few milliwatts. Pick-up and drop-out values can be closely set. Lightweight armatures and adjustable gaps are characteristic of this type.

same. However, when the thermostat is heated to the point that the high contact closes, the circuit is from L_1 to resistor, H, C, A, and L_2. This flow by-passes CR, causes the contacts A and B to open, and disconnects the load circuit. The resistor prevents the line from being short-circuited when the relay coil is shunted by the thermostat contacts.

Miniature Relays

Miniature magnetic relays represent a comparatively recent development in the field of electric control devices for industrial purposes. Their primary use is in industrial electronic equipment when space for components is extremely limited, when circuit currents are below two amps, and when operating voltages are not in excess of 115 volts.

A typical miniature magnetic relay of the metal base type relays is illustrated in Fig. 5. It is equipped with double-pole, double-throw, silver to silver contacts and solder-type terminals. On miniature relays, there is no provision for magnetic blowouts. To keep the overall dimensions as small as possible and for convenient installation, both coil and contact connections terminate at an insulating panel that is mounted at one end of the relay frame.

Sensitive Relays

Magnetic relays of the sensitive type are those that operate on small amounts of power, usually on the order of several milliwatts. Most designs like the one shown in Fig. 16

have lightweight armatures, and provision for adjusting the contact gaps and tail-spring pressure to obtain the desired pick-up and drop-out values. Although average coil power consumption is considerably lower than miniature type relays, the contact ratings compare favorably. However, it should be noted that sensitive relay contact ratings are extended to 230 volts. These higher ratings are advantageous in many applications since they eliminate the need for auxiliary relays.

Sensitive relays can be operated on either alternating or direct current. Their pick-up and drop-out values can usually be set within 15 percent of each other. For example, if a sensitive relay is selected having a nominal coil current of 100 ma, the pick-up could be set at 90 ma while the drop-out could be set at 76.5 ma or 85 percent of pickup setting.

It is important to distinguish between close-differential relays and sensitive relays. The former type is primarily for voltage regulating and battery charging applications where a relay is required that must pick-up and drop-out within a few percent of nominal voltage. Coil wattages sometimes approach those of heavy duty magnetic relays.

Time Delay Relays

When applying time delay relays in industrial controls, such factors as the time delay required, accuracy, timing range, (if adjustable), voltage, frequency of operation, contact rating and others should be carefully studied to insure satisfactory performance. These factors are so complex that nothing more can be done in this article than to mention them, even though, dependent on them is the selection of the type of timing relay that is to be used—i.e., motor driven, thermal, dashpot, mechanical escapement, capacitor, slugged, or others.

An interesting a-c timing relay that is widely used for process, machine tool, signal, and other timing control applications is the motor driven time delay relay with composite connections. This relay, shown in Fig. 7, is useful when it is desired to stock only one type of relay for either instantaneous or maintained contact operation. Basically, the relay consists of a small synchronous motor, a differential gear system, a built-in brake assembly, and a midget magnetic relay that is enclosed in a dust-proof cover.

Two timing sequences are obtained by connecting external jumpers provided on the relay terminal board.

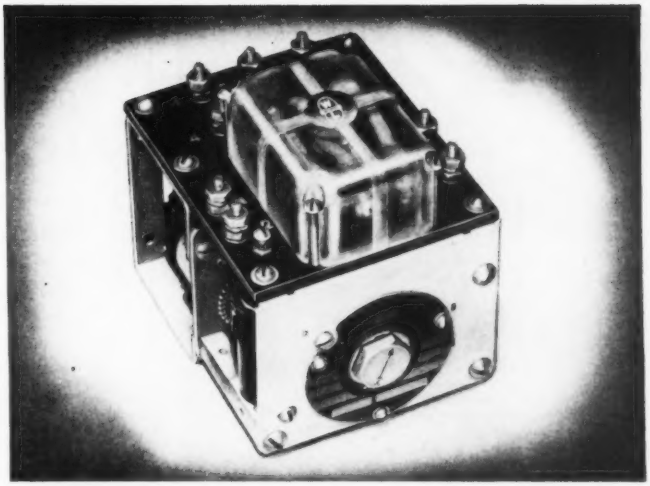


Fig. 7—Motor driven time delay relay with composite connections. This unit consists of a synchronous motor, a differential gear system, a midget magnetic relay, and a built-in brake. Two timing sequences can be obtained with this partcular model.

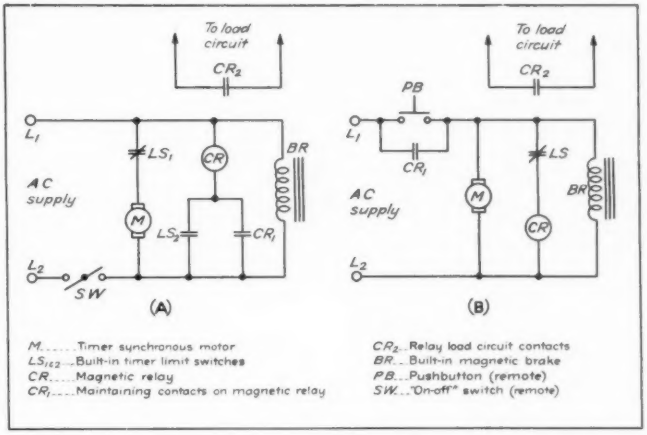


Fig. 8—Elementary diagram for motor-driven time delay relay (A) connected for a delayed make with two wire control; (B) connected for instantaneous make, delayed break, with momentary contact pilot circuit. External jumpers switch circuits.

With one set of connections, Fig. 8(*A*), "delayed-make" with a maintained pilot circuit is provided. Closing switch *SW* energizes built-in magnetic brake *BR* and timer motor *M*. The magnetic brake applies to one gear in the differential gear system, effectively engaging the motor. The timer motor drives a gear that rotates a limit switch contact arm. After a preset timing interval, limit switch contacts LS_2 close and LS_1 open. This action de-energizes the motor and energizes relay *CR* to close the load circuit. Both relay *CR*, which is maintained through contacts CR_1, and the magnetic brake remain energized until switch *SW* is opened, whereupon the auxiliary relay *CR* drops-out and the brake releases. The motor is then effectively disengaged, the gears are spring-returned to their initial position, and the timer is set for another timing operation. With the other connection, Fig. 8 (*B*), "instantaneous-make" and "delayed-break" with a momentary contact pilot circuit is obtainable. On momentarily

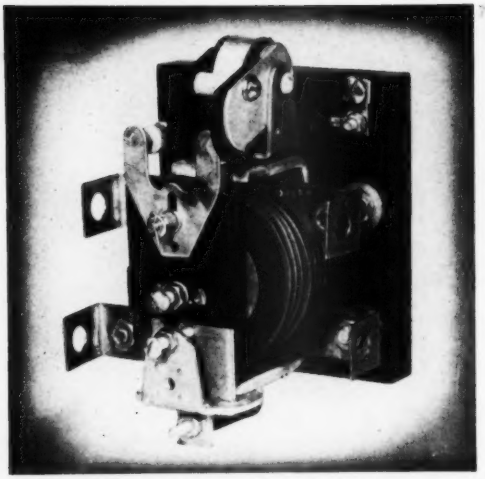


Fig. 9—Vibrating field relay, with double-break contacts and magnetic blowouts. Heavy series coils carry armature current.

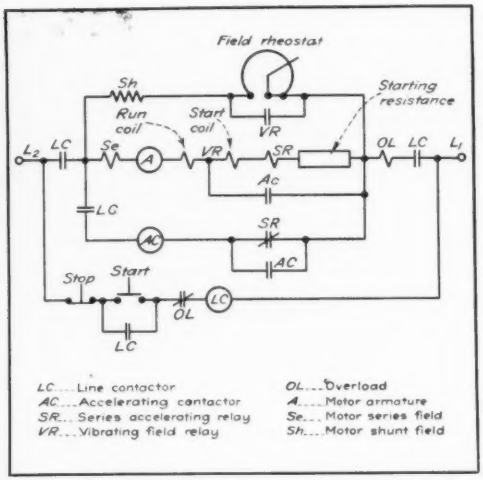


Fig. 10.—Diagram of typical d-c magnetic starter with vibrating field relay to give full field starting and smooth acceleration.

depressing pushbutton *PB*, relay *CR* picks-up, brake *BR* becomes energized, and timer motor *M* starts. On completion of the pre-set timing period, contacts *LS* open. This de-energizes relay *CR* which disconnects motor *M* and releases brake *BR*, thus allowing the timer to recycle.

Field Relays

Field relays such as shown in Fig. 9 are used in d-c motor starters and controllers for field failure protection, automatic acceleration or deceleration, or other purposes. These relays usually are of single-pole construction with normally-open or normally-closed contacts, and are equipped with magnetic blowouts. Armature and contact assemblies are light in weight, and armature travel from open to closed position is relatively short to facilitate rapid operation. Single or double operating coils can be furnished for series connection in motor armature circuits. Most field relays are provided with adjustments for magnetic air gap and tail-spring and contact pressure, so that the relay pick-up and drop-out values can be set to conform with requirements.

A typical application involving a dual coil, current-operated, field relay commonly known as a "vibrating field" relay is illustrated in Fig. 10. The relay performs two functions: that of a full field relay, and of an accelerating relay.

Both relay coils (start and run) are connected in series with the motor armature. During initial acceleration, the relay remains closed, thus short-circuiting the field rheostat and providing full-field starting. When accelerating contactor *AC* closes, the start coil is short-circuited and the relay drops out. Any insertion of rheostat resistance in the motor field causes current surges in the motor armature as the motor accelerates. These current surges, in turn, cause the relay to open and close with a vibrating action that inserts and short circuits the rheostat to provide smooth acceleration. When max motor speed, as determined by the setting of the rheostat, has been reached, the relay drops out.

Series Relays

Although any magnetic relay equipped with a series operating coil may be referred to as a "series" relay, the type of series relay depends on its use. For example, a series accelerating type is designed for d-c motor starter applications, determining the point in the starting cycle at which the starting resistance will be shorted out.

In d-c motor accelerating applications, the coil is connected in series with the motor armature. The relay is generally set to pick-up at 125 percent of normal full-load motor current and drop-out at 110 percent. Since high speed operation is essential, relay contact and magnetic gaps are short. Low average contact ratings from 1.0 to 2.0 amps, 115v d-c, are usual, as the relay normally pilots magnetic contactors. When the contact rating must be increased or when contact arcing is severe, condensers are sometimes connected across the contacts.

Series relays similar to the one previously mentioned, except furnished

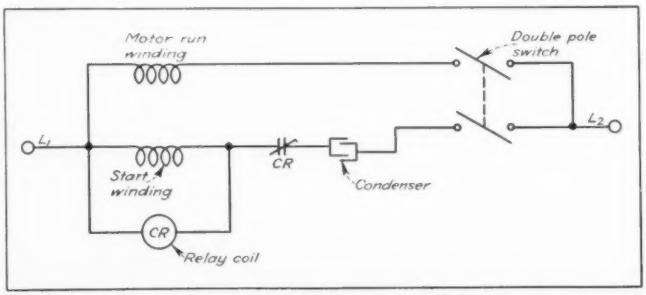


Fig. 11—Typical circuit digaram using potential relay for starting capacitor motor. The relay automatically opens the starting circuit when the motor reaches full speed.

with three series operating coils, are used occasionally for accelerating purposes on a-c primary resistance starters for squirrel-cage induction motors. They are also applied as jamming relays on secondary resistance controllers for a-c slip-ring motors. In such applications, the relay functions to insert resistance in the motor secondary to limit motor overloading during high peak-load periods.

Special Relay Types

CAPACITOR MOTOR STARTING RELAYS. Although there are several ways of starting capacitor motors, magnetic relays are frequently preferred since they provide positive and reliable performance. Another advantage is that they can either be built into the motor housing or mounted externally. Typical applications include industrial air compressors, motorized tools, and pumps.

Equipped with single-pole, normally-closed contacts, potential type capacitor-start relays are designed to function over a wide range of voltages. In operation, the relay contacts automatically open the circuit to the motor-start winding and condenser when the motor attains full rated speed, as indicated in Fig. 11. For standard applications the relay is set to pick-up at 130 percent of running voltage and drop-out at 35 percent of the pick-up voltage.

Since starting current constants for capacitor motors vary with the motor manufacturer, type of load, and type of service, each application should be checked under prevailing load conditions. When pick-up and drop-out values are non-standard, the max and min voltage of the starting winding should be obtained under running conditions to determine the "holding range" of the relay. In addition, the voltage at the instant this winding is to be disconnected, with the motor accelerating, should be known to obtain the proper pick-up voltage.

Of course, other types of starting relays besides the potential type are available for capacitor-motor starting. One is the series or current type, which has normally-open contacts and series operating coils. This relay operates on motor in-rushes and performs a similar function, that is, to disconnect the starting winding after full speed is attained.

Another type uses a thermal timer in conjunction with a voltage relay. Although both of these latter units have been widely used in past years, the potential type is gaining favor with some manufacturers because it may be used for motors of various sizes, the max limitations being determined by the max rating of the relay contacts. Also, the adjustments are not as critical as those of the series or thermal types.

LATCHING RELAYS. Latching relays are used when low power consumption is imperative, when operating voltages and/or frequencies are subject to fluctuation, or when noise or hum in a-c operation cannot be tolerated.

One common latching relay, known as a "mechanically-latched, electrically-reset relay" consists of three basic parts: a magnetic relay, a mechanical latch, and a reset magnet. On latching relays, no distinction is made between normally-open and normally-closed contacts since any set of contacts can be considered open or closed depending on which coil is selected as the main operating coil.

With both relay coils de-energized and the latch tripped, the relay contacts may be considered in the open position, as shown in Fig. 12. Momentarily depressing pushbutton, PB_1 energizes the main coil, A, and closes the relay armature and contacts. The relay armature is held closed by the mechanical latch. Momentarily depressing pushbutton PB_2, energizes the reset coil B, which trips the mechanical latch and allows the relay armature and load contacts to open.

When automatic pilot devices are used in place of manually controlled pilot devices, latching relays with auxiliary contacts, as indicated in Fig. 13, are generally used. When the C to H circuit opens, the position of contacts remains unchanged since the relay armature remains in the open position. As soon as the C to L circuit closes, the operation sequence is as follows: Coil B becomes energized; the relay armature closes and is held closed by the mechanical latch; lower interlock contact opens, de-energizing coil B; upper interlock contact closes setting up the circuit for coil A; relay load contact D closes, connecting load to power supply. Thus, auxiliary contacts interlock the circuit and prevent the coils from being energized continuously.

The operating coils of standard latching relays are designed for continuous duty; on units equipped with auxiliaries, they are suitable for operation on either a-c or d-c. For example, relays supplied with 115v, 60 cycle coils may also be used on 115v d-c or 230v a-c. Intermittent operation on higher voltages than the continuous duty or nominal coil rating is permissible; on voltages below this rating, the relay may fail to close or open properly.

If instantaneous over-current protection and an electrical reset feature is required, a modified form of the latching relay may be used. The main shunt coil is simply replaced with a series wound coil, the main relay contacts being normally-closed (armature open). When the current flowing in the series coil reaches a max value, the armature closes and opens the normally closed contacts. Resetting after the overload is done by momentarily energizing the reset coil.

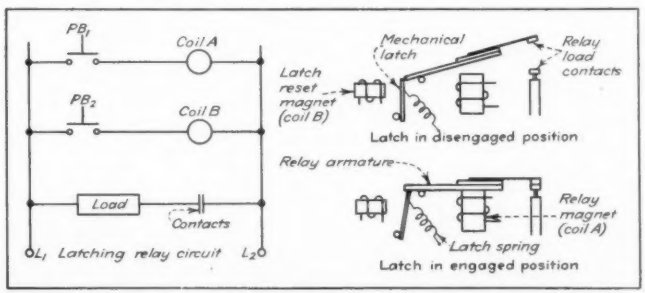


Fig. 12—Schematic diagram on left shows typical control circuit utilizing mechanically-latched, electrically reset relay, pushbutton-operated.

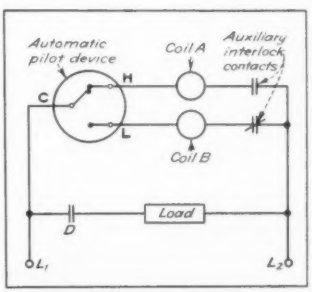
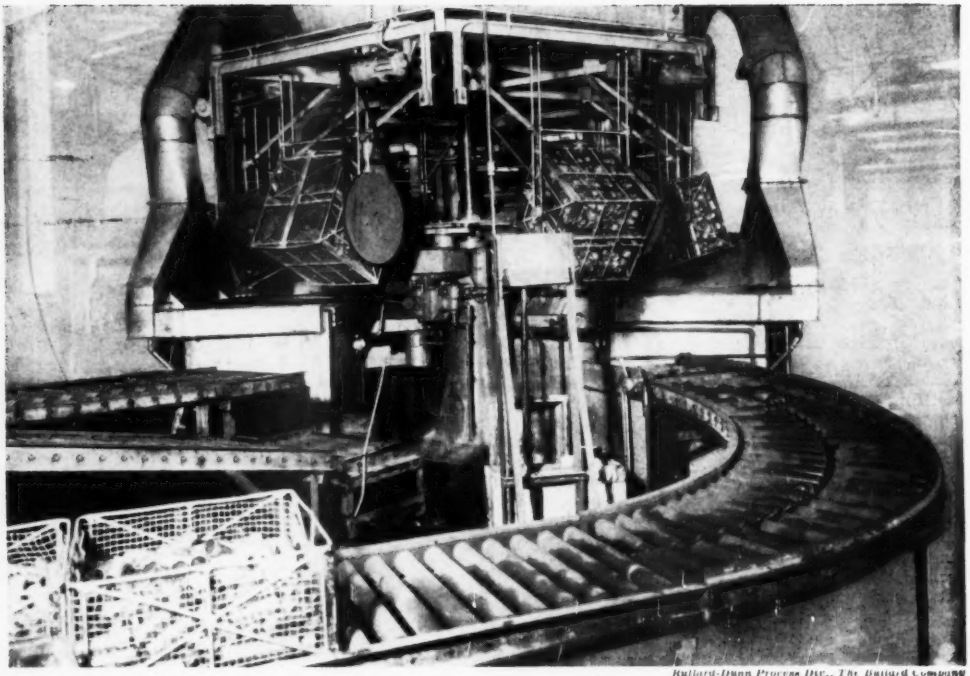


Fig. 13—Latching relay with coil interlock contacts, automatically operated.



Bullard-Dunn Process Div., The Bullard Company

SMALL BRASS PARTS are economically plated with automatic equipment. Pickling cycle previous to plating is speeded in this station-type conveyor. Such equipment can be used to apply various inorganic dips to all types of small metallic products.

Selecting Economical Inorganic

Copper, ferrous and zinc alloys can be given practical corrosion protection with chemical surface coatings and electroplates. In many applications, choice of a particular coating depends on the optimum combination of beauty and utility desired. Zinc and other die castings require special electroplating procedures.

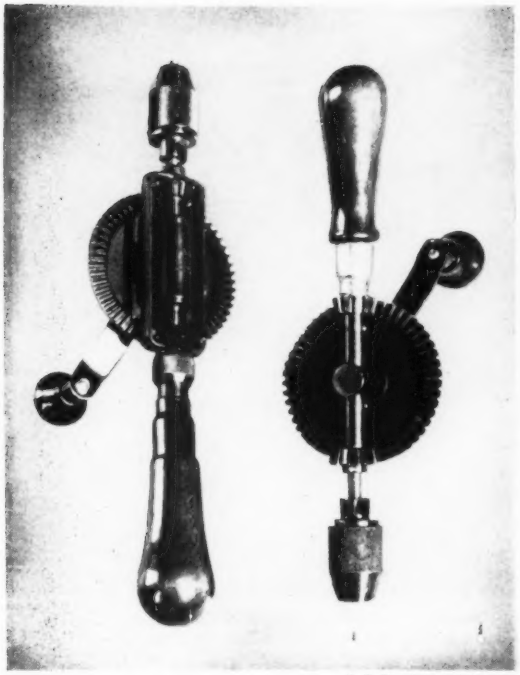
JEROME L. BLEIWEIS
Metal Finishing Consultant

PRACTICALLY ALL the plateable metals can be deposited on the copper base alloys for any specific application. Many of these plates give positive corrosion protection for copperbase alloys—as might be expected from a consideration of the Electromotive Force Series (see Table II, page 115, Sept. PRODUCT ENGINEERING). Tin is widely used for this purpose. Zinc however, is rarely deposited on the copper base alloys, because of its tendency to form surface alloys by diffusion, with a consequent loss in total strength. Cadmium is occasionally plated; it finds specific application where brass or bronze are to be placed in contact with aluminum. Cadnium plating the brass or bronze and aluminum lessens the disintegrating effects of galvanic corrosion.

When copper-zinc high brass is used, a high quality finish is required. Polishing, buffing and plating are more easily and inexpensively performed on this alloy than on any other in the brass family. For the combination of decorative and corrosion resisting qualities, brass is usually nickel plated before the final metal plate is applied.

A typical chromium plating cycle for brass includes the following steps: Assuming the parts are oil soaked and have a surface scale, they will be vapor degreased, and "bright dipped" in the usual sulfuric acid-nitric acid dip. The parts are rinsed and dried, and polished and buffed or just buffed. The work is then cleaned in an alkaline cleaner, rinsed, pickled in muriatic acid, rinsed, and bright nickel plated for as long as the specification requires. Bright nickel plating, usually as an undercoat for chromium plating, reduces finishing costs with no sacrifice of quality. Without having to buff any further, the work is rinsed and transferred to the chromium plating bath for 90 seconds, rinsed, and dried. Instead of chromium many other metals can be plated over the nickel for decorative purposes, except stannate tin which requires some other metal between the nickel and tin. Gold, silver, rhodium, and copper are "flashed" over nickel plated brass.

A large number of oxidized or sur-



E. F. Houghton and Company

STEEL TOOLS are blackened with a proprietary, hot alkaline dip containing an oxidizing agent. Coating can be applied to parts in bulk.

Parker Rust Proof Company

IRON AND STEEL PARTS are given proprietary phosphate coating (Parkerizing) for increased wear resistance.

Finishes

face conversion finishes can be applied to the copper base alloys. The most widely used are the "black" sulfide coatings formed by immersion in aqueous sulfides; they vary from brown to black depending on the treatment time, and can be wire brushed to bring out highlights. The resulting finish resembles old copperware and is known as an "antique" finish. A great many other color effects can be obtained. These coatings are generally lacquered for preservation. Frequently black oxide coatings are specified on brass as paint bases where better paint adhesion and surface life than obtainable on uncoated brass are required.

Ferrous Metals

Although electrochemically more inactive than magnesium and aluminum, steel corrodes and disintegrates more rapidly than these two in most environments. Light metals form thin impervious corrosion products which spread superficially along its surface and retards further corrosion; steel forms a loose, porous rust formation which progresses perpendicular to the surface. The rust is also more "noble" than the uncorroded steel, thereby accelerating corrosion of the steel around and under it.

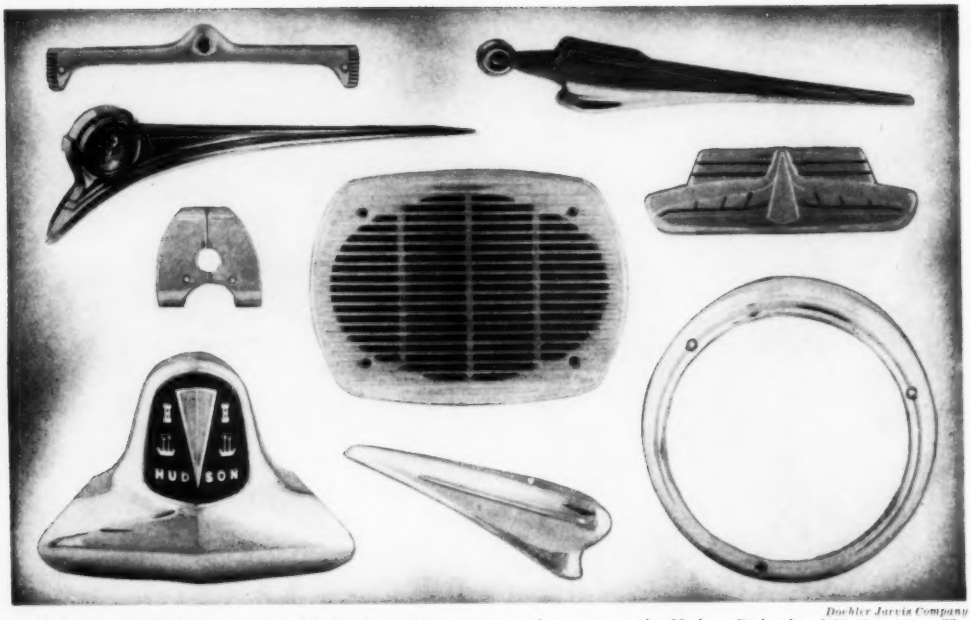
For large, outdoor structures the only practical method for protecting steel against corrosion is painting. This can be preceded by brushing on a derivative of phosphoric acid, which forms a phosphate conversion coating on the steel. This coating acts as an adhesion base for the paint to be applied and also retards the spread of rust under the paint. The first organic "finishing" step is usually the application of a red lead primer. Finally, the top coats are applied.

Steel which is stored, either fabricated or unfabricated, can be preserved economically by coating with a rust retarding oil especially marketed for this purpose.

For minimum corrosion resistance or for applications requiring an adherent paint base, there are a number of phosphate treatments for steel, similar to the well known bonderizing and parkerizing treatments. These treatments are applied by immersing the degreased, cleaned, and pickled steel articles in a solution of a phosphoric acid salt for the prescribed period of time. Two commonly used salts are the zinc or manganese dibasic acid salts of phosphoric acid. Since phosphate coatings are absorptive, the corrosion resistance of phosphated steel can be increased by impregnating the coated steel with oil or waxes.

The phosphate processes are inexpensively and easily applied; no current is required and the parts are amenable to bulk handling. However, for optimum corrosion resistance, particularly in severe outdoor environments, additional protection is necessary.

For additional corrosion resistance on steel articles, the two most widely used coatings are zinc and cadmium plates. Zinc and cadmium are the only two commercial electroplates which protect steel by the sound method of electrochemical action (see Tables I and II, page 134, Sept. 1949 PRODUCT ENGINEERING). Wherever bare steel



Bochler Jarvis Company

COMPOSITE COATINGS of copper, nickel and chromium are plated on these zinc-base die cast grilles, dashboard parts and exterior ornaments for Hudson, Packard and De Soto cars. The depressed lettering is filled in with black enamel.

shows through a cadmium or zinc plate, the zinc or cadmium corrode preferentially and the more noble steel is protected cathodically. The corrosion products formed on cadmium and zinc are "self sealing", retarding the spread of corrosion. The protective value of zinc or cadmium coatings is a function of their thickness.

The materials going into the zinc plating process are considerably less expensive than those used in cadmium plating; the cost ratio of raw materials is about 1 to 8. However, there are two opposing schools of thought on the question of zinc vs cadmium plating. The cadmium proponents claim that the corrosion protection offered by cadmium is as at least as good as that offered by zinc and that the bulky, unsightly corrosion products formed by zinc in humid or saline atmospheres are not formed by cadmium. The zinc proponents point to the higher electronegative potential of zinc, and the "passivating" chromate dips, which greatly reduce the bulk of corrosion products. Zinc plated and appropriately passivated storm window hinges have been exposed by the writer for more than a year with absolutely no surface discoloration. Where no passivating dip is used, cadmium plating is preferred on closely fitting or threaded parts. However, considering the lower price of zinc plus the fact that passivating treatments are so effective, it is probable that zinc will more and more displace cadmium as a corrosion retarding electroplate for steel.

Zinc is deposited from either an acid sulfate or a cyanide bath, and cadmium from a cyanide solution. In general, the cyanide solutions have wider applicability than the acid baths. Both cadmium and zinc plating baths, by the addition of suitable brighteners, deposit semi-lustrous electroplates which combine corrosion resistance with attractiveness. Bright dips after plating also enhance the luster of the deposit and they also passivate the plated surface.

Barrel plating is an economical method for small parts; the bulk handling usually lowers the plating costs to from 5 to 15 cents per lb of work.

Other metals—notably copper, tin, nickel, silver, lead and brass—can be deposited on steel for corrosion resistance; however, for maximum protection, the deposit must be pore free —must form a continuous envelope around the steel. These metals are more noble than steel, and wherever bare steel is exposed, corrosion is accelerated within the exposed area. Nevertheless, for many applications, steel is plated with a more noble metal. Steel-base food handling equipment, ice trays and cans for food are tin plated, since under conditions existing on the inside of tin cans, it is claimed that tin is anodic to steel and protects steel in the same manner as zinc and cadmium. Zinc and cadmium, however, are not suitable for plating food handling equipment because they are extremely toxic. Silverware is frequently heavily silver plated steel.

Where reflectivity as well as corrosion resistance is required, steel is plated with several metals as final coats; copper and nickel or nickel alone are usually intermediate deposits. A typical cycle for chromium plating steel products where corrosion resistance and high reflectivity are required, would be: Polish steel (grit size depends on initial condition of steel); finish polish with 220 grease wheel or buff with greaseless type compound; copper plate and buff or bright copper plate (0.0002 in.); bright nickel plate (0.0003 in.); chromium plate. Other metals, such as gold, silver or brass, can be substituted for chromium as the final specified coating; the copper and nickel provides corrosion resistance.

There are many special applications for other deposits on steel. Lead plated steel is used for acid sulfate environments; brass plated steel as a base for bonding rubber to steel;

Table I—Economy vs Utility of Coatings on Ferrous Metals

Coating	Use	Economy and Utility Relative to other Coatings
Film of rust retarding oil	Rust preventive during storage	Very economical but is only applicable where parts are stored. Not practical for service use.
Phosphate coatings	Paint, oil, or wax base	Economical to apply. Some corrosion resistance is obtained but for best results, coating should be used as base for further materials. Specific use as an "oil holding" wearing surface on piston and cylinder walls.
Cadmium plating	Corrosion resistance	Excellent resistance to corrosion. Economical, although not so much as conversion coatings. Particularly economical where barrel plating is possible. Thickness should be 0.00015 in. for mild service and 0.0005 for severe service.
Zinc plating	Corrosion resistance	On a par with cadmium above, utilizing materials far more inexpensive than in cadmium plating.
Tin plating	Corrosion resistance	Used on food handling equipment and containers because of its non-toxic nature.
Nickel, or copper followed by nickel	Decorative under coating	Relatively expensive process. Used as undercoats for chromium, gold, where sales appeal is required. Nickel frequently used as final coating.
Brass	Bond for rubber or decorative	
Hard chromium	Build up undersized parts, prolong tool life	Expensive process where build up is required. However, salvage value often warrants use.
Black oxide	Blackening steel	Very economical where a black colored steel product is desired.

iron, nickel, or hard chromium plating to build up worn or undersized parts; and porous chromium to provide wear resistance low friction surfaces.

A widely used conversion coating on steel is the jet black, somewhat absorptive iron oxide coating formed in hot concentrated caustic solutions. This coating serves as an economical black finish on steel capable of being applied to parts in bulk. It has some corrosion resistance, increased by oil immersion, but the coating is not notable in this respect.

Porcelain enamel, an inorganic refractory coating is also used widely for coating steel, on cooking utensils, stove tops, and similar applications. However, it is not within the scope of this article to evaluate these refractory coatings.

There are some limited applications for the plating of "corrosion resistant" or stainless steels. For ornamental purposes, such as the gold plating of stainless steel watch bands, a combination of the anti-corrosion properties of stainless steels plus the visual properties of whatever the final plate is to be, may be required. The very property of these steels that makes them so corrosion resistant also makes them difficult to plate in the conventional manner. This property stems from the existence on the stainless steel of a thin but impervious "self healing" coating of chromium oxide. The procedure for plating, to overcome this difficulty, is as follows:

1. Alkaline clean and rinse;
2. Pickle in 50 percent by volume muriatic acid and rinse;
3. Strike in a nickel plating solution of the following composition: Nickel chloride 2 lb per gal; muriatic acid 1 pint per gal; water to make 1 gal; 6 volts dc at room temperature using nickel or gas carbon anodes.
4. Plate in a conventional manner.

Failure to employ this modified procedure will result in peeling of whatever is plated on the steel. Table I sums up the processes described for ferrous metals.

Zinc Die Castings

Zinc die castings must be coated in some manner, for without protection they turn dark; or in humid or saline atmospheres they form bulky white corrosion products.

There are a number of surface conversion coatings available for zinc die castings. These include passivating chromate dips, phosphate dips, and proprietory blackening processes for a combination of appearance and cor-

Parker Rust Proof Company

EFFECT OF OUTDOOR EXPOSURE for one year on untreated steel panel (left) and on phosphate coated steel panel. After removing corrosion products, it was found that panel at left was perforated in many places and lost 33 percent of its weight. Treated panel was sound, and lost only 10 percent of its weight. For best resistance, organic coating is applied over phosphate.

rosion resistance, particularly when lacquered. The chromate dips passivate the surface; in addition, some impart an attractive brassy golden color to the casting, which is a visual improvement over the normally grayish cast. These conversion coatings are economical and, particularly when painted, are suitable for zinc die castings unless a highly reflective coating, usually chromium is required; then the only answer is electroplating.

When zinc die castings are plated, a nickel plating operation must be included to maintain sustained quality. Copper, brass, gold or silver, plated directly on the die casting, slowly diffuse into the casting with consequent deterioration. To prevent this difficulty, special die cast nickel coatings are deposited directly on the casting, or more usually conventional or bright nickel is plated a previously deposited cyanide copper undercoat. The plating process is more expensive than the other processes, but it "dresses up" a zinc die casting to a far greater extent.

Lead Base Alloys

Lead base alloy parts are plated for appearance primarily. Buffing of the metal does not result in the high finish desired. The intrinsic softness and low temperature flow characteristics cause a "dragged" or diffuse appearance on buffing. However, by buffing for smoothness, plating, and coloring where required, a highly buffed effect is obtained. A typical cycle would be:

New Jersey Zinc Company

FRONT RING of the new "Heat King" electric room heater is die cast of zinc and then chromium plated. Drawn steel support tube is also chromium plated.

Table II—Electroplated Coatings

Deposited Metal	Basis Metal	Applications
Brass	Any	Base for rubber adhesion. Decorative coating for the purpose of matching pure brass or bronze.
Cadmium	Steel	Corrosion resistance {0.00015 in. mild service 0.0005 in. severe service
Cadmium	Brass, or bronze and aluminum	Corrosion resistance through prevention of galvanic corrosion.
Chromium (decorative)	Any (used on nickel undercoat)	Decorative—plated 0.00001 to 0.00002 inches thick.
Chromium (hard)	Any (direct or on copper or nickel undercoat)	Wear resistance on tools as taps, reamers, broaches, files and cams, on molds for plastic or rubber for longer life and maintenance, of smooth finish. Hardness and wear on dies Heavy coatings for build up of undersize parts.
Copper (acid)	Plastics, glass, stainless steel, other materials	Initial electroplated coat on non metallics. Electroforming and electrowinning. Protective coating for the silver on glass mirrors.
Copper (cyanide)	Steel	Undercoat for buffing on which nickel and chromium are deposited. As a "stop off" for selective carburization of steel.
Copper (cyanide)	Zinc die castings	Undercoat for nickel.
Copper (cyanide)	Aluminum	Undercoat for nickel.
Gold	Any	Resistance to tarnish and attack by chemicals. Sales appeal of gold. Resistance to oxidation at elevated temperatures. Plating of laboratory apparatus for protection against corrosive fumes. Infra-red reflectors.
Iron	Any	Electroforming. Building up worn or undersized parts.
Lead	Any	Resistance against various acids and chemicals.
Nickel	Any (frequently on copper undercoat)	*Undercoat for decorative chromium* or other decorative metals. Building up worn or undersized parts. Corrosion Protection of brass, steel, and zinc die castings. Electroforming.
Rhodium	Nickel undercoat	Hard, tarnish resisting, highly reflective coating.
Silver	Any	Decorative. Eating utensils. Electrical parts to decrease contact resistance. Electrochemical measuring instruments. Surgical apparatus. Musical instruments.
Tin	Steel, brass, others	Corrosion resistance particularly for food handling equipment. Anti scuffing or seizing coating on cylinder and piston surfaces.
Zinc	Steel	Corrosion resistance.

Buff, clean and pickle (short time for both); plate copper and color or plate bright nickel; "flash" plate final plate (chromium, gold, silver).

There are many coatings, particularly plated coatings, which have specific uses, relatively independent of the basis metal upon which they are applied. Most plated metals can be deposited on most of the basis metals discussed previously, with different effects. Table II lists all the commonly plated metals with their general and some of their specific applications.

EDITOR'S NOTE: The coatings described in this series (see "Inorganic Finishes for Light Metals" by J. L. Bleiweis, September issue) are not presented as the complete answer to all coating problems. In forthcoming numbers, PRODUCT ENGINEERING will present a similar discussion on the organic finishes.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Double Turboprop Engine for Small Aircraft

Foreign abstract from "Double Mamba Gas Turbine Propeller Engine," (London), p 415, May 9, 1949.

THERE IS A DEFINITE TENDENCY in Great Britain toward using aircraft engines coupled together to form single power units. So far, this arrangement has been confined to the larger types of aircraft. There is a possibility, however, that the idea of coupled engines will be extended soon to smaller aircraft.

Armstrong Siddeley Motors Limited, Coventry, announced recently the introduction of the Double Mamba, which consists basically of two Mamba II gas turbines placed side by side. Although the two engines are joined together at the front, mainly by means of the air-intake casting and propeller-shaft reduction-gear casing, they are otherwise two separate power units with their own fuel, lubricating and control systems. Each engine is provided with its own reduction gearing, which is arranged to drive one of two counterrotating coaxial propellers.

The small over-all diameter of the Mamba makes it possible to obtain an exceptionally compact power unit with this arrangement, and the over-all dimensions are such that it may prove possible to fit the unit into single-seat naval aircraft, thereby giving a considerably greater factor of safety. The manufacturers claim that the combination will give a high power-weight ratio for maximum-power operation with considerable economy in fuel consumption when cruising at low powers.

The combined compressor and turbine wheels rotate at a speed of 15,000 rpm, which is reduced to a propeller-shaft speed of 1,450 rpm by a reduction gear of 0.097 to 1 ratio. This reduction is obtained by a combination of epicyclic and ordinary spur gearing, the port engine driving the front propeller, and the starboard engine the rear propeller. Each engine is provided with its own epicyclic reduction-gear unit, which is driven through a helical-tooth sun gear fitted to the forward extension shaft of the compressor. The sun gear meshes with the larger gears of three compound planet gears, the smaller gears of which mesh with a fixed gear ring. Both the smaller planet gears and the fixed gear ring have spur teeth. The front of each planet-gear carrier is fitted with a spur gear, which, on the port engine, drives a gear fitted to the propeller shaft through an idler; and on the starboard engine, drives the propeller shaft through two idlers, the extra idler being provided on the starboard engine in order to give counterrotation of the propellers. Apart from the extra idler, however, the two gear trains are identical.

Each sun gear has 27 teeth and rotates at engine speed, namely, 15,000 rpm. The helical planet gears have 38 teeth and the spur planet gears 15 teeth; both rotate at 2,116 rpm. But owing to the action of the 63-tooth fixed gear rings, the carriers, and therefore the integral spur gears, rotate at 2,170 rpm.

On each engine the auxiliaries are fitted at the front and rear of the auxiliaries case, which is located just behind the air intake and engine-mounting casting. The drive is transmitted from the propeller, shaft reduction gear through a single inclined bevel shaft that passes through one of the airfoils in the intake.

The complete unit has a width of 52.8 in. and a height of 42.35 in. The over-all length, measured from the rear face of the propeller-fitting cone to the rear face of the turbine housing is 79.83 in.; the dry weight is 2,000 lb. Under sea-level conditions and at maximum take-off rating of 15,000 rpm, the propeller-shaft horsepower is 2,540 and the net jet thrust 770 lb, while for maximum continuous cruising at 14,000 rpm, and an air speed of 300 mph, the propeller-shaft horsepower is 2,300 and the net jet thrust 225 pounds.

Collecting Standardization Data

From "Collecting Standardization Data" by J. R. Townsend, *Standards World*, Summer 1949, Vol. 1, No. 3.

IN THIS ARTICLE the Past-President of the ASTM has revised and expanded the original article published in the ASTM *Proceedings* in 1933.

Standardization data is needed in determining the distribution of quality characteristics for materials, in setting economic standards of quality, in comparing the relative merits of two or more materials for particular use, in controlling quality at desired levels, and in predicting what variations in quality may be expected in subsequently produced materials. They also aid in discovering the distribution of errors of measurement in particular test methods, in specifying the precision of standard tests and in setting up economical testing and sampling procedures. They assist in determining relationships between two properties of materials or between indirect measures or direct measures of physical properties. They may be used to find the physical causes of the behavior materials under particular service conditions and to reveal the causes of non-conformance of specification standards, with the aim of eliminating assignable causes and securing economical control of quality.

The first part of the article covers the general consideration in establishing quality standards, specification limits and methods of tests. Methods of drawing of specification requirements are then analyzed. The items to be considered in the collection of standardization data are then listed and discussed. These items are:

1. Statement of the problem.
2. Selection of investigation personnel, if necessary.
3. Analysis of the problem.
4. Collection and review of all pertinent prior knowledge.
5. Division of the problem in physical and chemical laws involved.
6. Segregation of those portions of the problem requiring separate investigation where prior knowledge cannot be used.
7. Selection of the testing equipment.
8. Selection of the exact conditions under which tests are to be made and the exact method of procedure.
9. Selection of methods of calibra-

tion of testing equipment to be used by one or more collectors of data.

10. Determination of method of drawing representative samples to be measured.

11. Statement of accuracy desired in final results for each sub-group of tests.

12. Collection of preliminary data.

13. Preparation of instructions to be followed in the collection of data.

14. Tabulation of data in sub-groups, corresponding to the several sets of conditions.

15. Observation of trend of results as investigation proceeds.

16. Presentation of data in a form leading to logical conclusions.

The pitfalls which are quite common in the investigation of work of this kind and which will result in bad data are summarized briefly. These pitfalls are:

1. Oversimplification of a test in order to obtain reproducible results.

2. Presupposition of the end result.

3. Lack of flexibility of program.

The author discusses the possible errors which may be made under each of these categories. The last part of the article gives several examples of planning for the collection of standardization data. These examples serve to illustrate the principles described earlier in the article. Numerous footnotes cover important publications.

Methods of Penetration Hardness Testing

From "Hardness Testing" by J. Winning, *Mechanical World,* June 3, 1949.

HARDNESS might be defined as resistance to penetration or abrasion, but not both, since it does not necessarily follow that the hardest materials on this reckoning are always the most abrasion resistant. Engineers have, of course, long recognised the fact that hardness is not a single well-defined property of matter, and for test purposes, at least, are agreed that two leading characteristics of metals and alloys best meet practical cases. These are resistance to penetration, as exemplified by Brinnell and similar test, Rockwell testing and the like, and, less commonly, abrasion resistance as in the Amsler test.

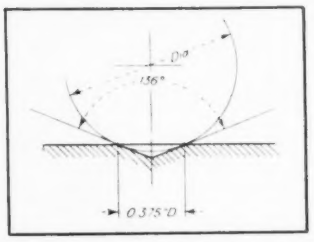


Fig. 1—Diagram showing the geometry of the ball and the pyramid indenters. The standard angle is 136 degrees.

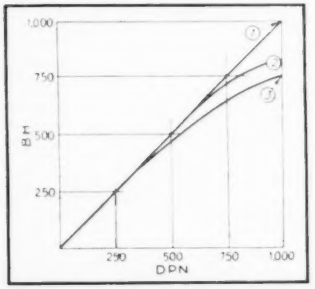


Fig. 2—Graph showing the relationship between hardness readings obtained by three different methods. (1) Standard diamond pyramid. (2) Ball loaded to give constant diameter impression (0.375D). (3) Regular Brinnell.

Principal of Brinnell Testing

In principle the Brinnell test consists of forcing a hardened steel ball into the surface of the metal under a fixed load. The size of the impression thus made is obviously a measure of the resistance of the material to this kind of deformation or penetration. In order to rationalize the numeral thus obtained, Brinnell takes the pressure on unit area (kg./mm²) required to produce the impression, as the hardness number. The Brinnell hardness is consequently a pressure. For some reason the spherical area of the impression was chosen in calculating this pressure, although it would have been much simpler and more rational to reckon the projected area. Unfortunately, all other developments of penetration hardness tests have followed Brinnell in order to keep the figures concordant. It now seems a pity that Brinnell's clumsy mathematics were not abandoned soon after his machine had proved its value in practical work. In most cases the rational figure would differ but slightly from the Brinnell figure, and could be computed readily from the diameter of the impression. (See Table I.)

Because a ball was used, presumably because ball bearings were readily available, the hardness numeral depends considerably on the ratio adopted between the load and the ball diameter.

Practical experience in the use of these ball indenting machines shows that there is an "optimum" depth for the ball to penetrate, on either side of which accuracy falls away for different reasons. If the impression is between a half and a quarter of the ball diameter, it yields reasonable and practical sensitiveness to differences in hardness. With a fixed load and ball diameter, of course, this condition limits the range of accurate readings.

Fig. 1 illustrates this condition diagrammatically. Here, a ball of diameter D is pressed into a surface to make an indentation of diameter 0.375D or 3/8D, that is, the mean position postulated above. The tangent to the point of contact in one plane, it will be observed, makes an angle of 136 degrees. This is the point angle chosen for diamond indenters of pyramidal shape (e.g. the Firth and the Vickers). Since the pyramid always makes impressions of similar geometrical shape, simulating conditions laid down as ideal for the ball, the (load diameter²) ratio is of no significance, and any load can be used according to requirements.

There is another method of attacking this problem, exemplified in the Monotron hardness tester, in which the ball is pressed into the specimen to a constant depth, the required load, in kilograms, being the measure of hardness. This, calculated as a pressure on the area of the impression, gives results

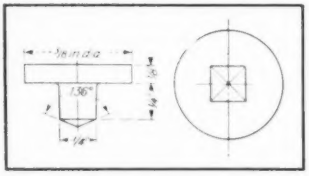


Fig. 3—Pyramid indenter to replace ball in standard Brinnell machine.

Table I—10 mm Ball and 3,000 kg. Load

Dia of Impression	Normal Brinnell No.	Corrected Hardness No.
2.5 mm	601	612
4.0 mm	229	329
6.0 mm	95	106

which are concordant over a wide range of hardnesses. Fig. 2 shows graphically how the three methods compare.

Diamond Testers

Since the diamond is the hardest substance known when tested by all accepted methods, such as crushing strength, ability to scratch other substances of comparable hardness (e.g. glass), high resistance to abrasion and the like, it is chosen as the standard penetrator. An industrial-type diamond, mounted on a suitable holder and polished to the required form, usually a square pyramid with a perfectly sharp apex of 136 deg angle between faces, is used as an indenter. The loads are chosen so that the diamond is not forced into the material beyond its largest dimensions, and normally only a comparatively small portion at the end is used to make the mark. The apparatus for these tests is precision made, since the diamond is not large enough to take heavy loads, and it is but seldom that loads of 120 kg. are exceeded in this type of equipment. It therefore becomes necessary to increase the sensitivity of the measuring device for measuring the size of the small square impression very considerably. This is accomplished by means of rather high-magnification measuring microscopes. These give an image of 20 to 30 times magnification, which can be readily measured to as little as 0.001 mm. It is assumed that the diamond is incompressible, that is it does not distort under load, and this is practically true, although the pressure on the sharp point must be very high. This last consideration makes it necessary that the load should be applied uniformly and with precision, otherwise there is grave risk of splintering the diamond, and various spring and oil dashpot devices are incorporated in the machines to ensure that no shock loading is possible.

On the above assumptions, then, the diamond is accepted as the standard for hardness testing, and the relation between hardness and depth of penetration should be linear. Fig. 2, curve 2, illustrates this. The ball, loaded to constant diameter impressions, gives exactly concordant readings up to about 600 D.P.N. but beyond this the ball itself begins to yield and gives distorted impressions. This is seen in curve 2 where it begins to diverge from the standard curve. The orthodox Brinnell hardness curve (curve 3) is even worse and shows considerable divergence at comparatively moderate hardnesses in the region of 300 D.P.N.

In view of the many advantages of the pyramid indenter over the ball, it is surprising that it has not been adopted more generally. It is not possible to use diamonds as large as, say, a 10 mm ball, but excellent and practical substitutes can easily be found. A pyramid of not more than 0.35 in. (8.89 mm) diagonal (Fig. 3) can be made of tool steel and readily adapted to take the place of the ball in the standard Brinnell machine. Such a pyramid gives much more accurate and easily read impressions than the ball, and does not distort any more than the ball at high hardnesses. Suitable materials for manufacturing these pyramids are 1 percent carbon-chrome ball bearing steel, any of the usual grades of high-speed steel, or even silver steel, all suitably hardened, of course, to the maximum obtainable. If precision grinding equipment is available, Stellite or Wimet would be even better. The fact that a variety of loads can be used to suit test conditions (e.g. light loads for testing thin materials) is most convenient, and considerably extends the usefulness of the equipment.

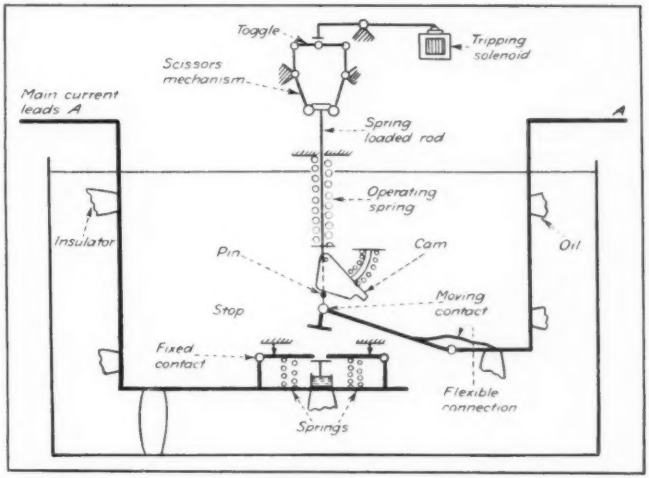


Fig. 1—This making switch mechanism is accurate to ±0.00016 seconds.

Consistently Timed Sudden Motions

From "Consistency of Timing Obtained with Heavy Trigger-Released Mechanisms," by L. Gosland and A. A. Hudson, *The Engineer*, April 8, 15, 1949.

TWO HEAVY MECHANISMS have been constructed to perform accurately timed sudden motions. The first is a switch for closing an electric circuit in about 0.03 sec with a consistency of ±0.00016 sec. The second is for breaking a circuit in about 0.03 sec with a consistency of ±0.001 seconds.

The closing switch is shown in Fig. 1. Activating the solenoid actuates a scissors and toggle mechanism to release the spring loaded rod connected to the moving contact. When the circuit is closed, a cam locks the moving contact in place through a pin attached to the contact. Before actuation of the solenoid, the cam is held back in a neutral position by this pin. Motion of the pin releases the cam, which is then moved into place by a spring. When the circuit is open, the fixed contact is pressed against a stop by springs. Closing the circuit forces the fixed contact away from the stop so that the contact is supported by the springs. Contact vibration is prevented by a dashpot attached to the fixed contact.

Since frictional effects account for most of the timing inaccuracies, they should be low as compared to inertia effects and hence the spring forces. Pin-joint friction torque is kept low by using pins small in diameter. Friction between the locking cam and the moving contact pin is limited by the shape of the cam curve. When both cam and pin are accelerated without pressure between one another, the cam curve

shape will cause them to be just touching one another. Further reduction in the importance of the frictional effects results from the high inertial forces and hence from the high spring forces. The spring force on the rod is 140 lb, about 100 times the resultant frictional forces. The force available for tripping the scissors and toggle mechanism is about ten times that required to overcome friction. Experimental data from oscillograph records of the current in the tripping circuit and a low voltage d-c circuit through the main contacts shows that the consistency of timing indicated above has been obtained.

The breaking switch mechanism is shown in Fig. 2. While the circuit is closed, current passes from a roller contact through a spring loaded rod to a plug, which forms the movable contact. The plug fits into a fixed contact in the form of the plug of a vessel containing air at pressures up to 35 atmospheres. Release through the scissors and toggle mechanism of the spring loaded rod removes the plug from the throat to break the circuit. The stopping dashpots prevent bouncing of the rod after it has completed its travel. Guides for the rod are provided to improve gap adjustment precision. To avoid an initial resultant force on the moving parts from air pressure, the rod diameter at the gland is equal to the throat diameter. Because of the resultant air pressure force developed upon removal of the plug from the throat, a compensating dashpot is added. This dashpot has a port of adjustable area to make it possible to obtain the necessary dashpot force.

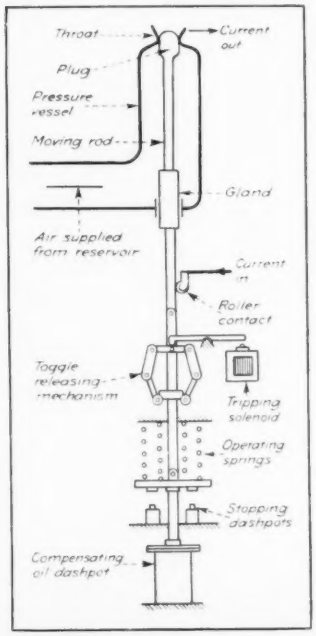


Fig. 2—**Breaking switch mechanism.**

As was done for the making switch, consideration was given to the reduction of frictional effects. Here, also, frictional torques of rollers were kept low by the use of small pin diameters. The use of a long gland with a clearance fit between rod and gland limits the friction between these parts. The use of rolling, rather than sliding, contacts to deliver current to the rod makes it possible to maintain a high contact pressure with little friction. Although the spring force on the rod is 800 lb the frictional forces are 20 lb, or about 2 percent of the spring forces. In addition, the ratio of inertia forces to frictional forces for the scissors and toggle mechanism is also less than that obtained in the case of the making syitch. However, oscillograph records of the current in the tripping circuit and of the travel of the rod show that the desired accuracy was obtained.

Nitrogen Case Hardening

Foreign abstract from "Developments in Nitrogen Case Hardening" by S. C. Churchill, *Mechanical World*, (Manchester, England), p 5, July 1, 1949.

SURFACE HARDENING of metals by common methods is primarily an enrichment of the marginal layers by a gas that reacts with constituents in the material. The reaction usually forms a new condition that may itself possess the quality of hardness or be capable of producing hardness in response to subsequent treatment. Nitriding is a particular case in the first category while carburizing is a generally recognized case in the second.

Both processes depend upon the mechanism of diffusion for the enrichment of the reacting constituents with the hardening media. In both processes the reaction at the surface is essentially gaseous.

In the nitriding process, the nitrogen is always presented to the surface of the material as a gas derived from synthetic ammonia. In its derived form the nitrogen is atomic, an essential to the success of the process. Gases composed of complex molecules cannot diffuse through solid metal.

In both nitriding and carburizing, the purpose is to produce a hard wear-resisting case at the surface of the steel. Carbon case hardness is limited to the ultimate hardness of martensite. The usual order of hardness obtainable in carbon steels, nickel or nickel chrome steels ranges from 650 to 700 Brinell. In nitrided steels the hardness ranges from 600 to 1,200 Vickers Pyramid Number; the hardness depending on the alloying elements in the steel.

In most steels alloyed for nitrogen hardening, the carbon content averages about 0.3 percent, with a range of 0.2 to 0.5 percent. Without an alloy addition a steel of this carbon content would nitride to give a maximum hardness of 300 Brinell, but the case would be extremely shallow. Such surface hardness results from the nitrides of iron, which are not very stable. Their hardening effect is not sufficient to make it technically interesting to engineers.

Among the numerous other elements that will combine with nitrogen to form nitrides are aluminum, copper, chromium, manganese, molybdenum, nickel, silicon, tungsten and vanadium. Four of these have value in securing desirable properties in the hardened case and the core.

Aluminum alone has a greater hardening effect than any other element, but the hardened layer is very shallow and tends to be brittle. The depth of case becomes more shallow as the aluminum content approaches its maximum hardening value. Chromium alone confers a greater depth of case, but the hardening effect is only a little better than half that of aluminum. With the addition of both elements in the optimum proportions, maximum hardness of case is combined with satisfactory penetration.

Molybdenum alone gives a penetration curve of excellent shape, but the extreme hardness is not high. This characteristic is of value in reducing the hazard of embrittlement in all nitriding steels, particularly in those in which high core strength is derived from the alloying of nickel and chromium.

While these alloying elements form nitrides that are stable between the temperature of nitriding and

room temperature, and confer high or extreme hardness in the surface margins, they have a retarding effect on the diffusion of nitrogen; this characteristic leads to a condition of nitrogen saturation at the surface.

The nitrides formed in this skin have the particle form and are less hard than the acicular nitrides that form beneath it. Where maximum wear resistance is required the surface skin should be removed by burnishing. The average depth of the skin is about 0.001 in. The average increase of hardness obtained by removing the skin is approximately 250 Brinell points for alloy steels containing aluminum. Steels that contain no aluminum gain about 100 points, but the harder zone is nearer the surface.

Carbon-chrome and carbon chrome-molybdenum steels nitride to give a maximum hardness of 800/850 Brinell with a case depth declining slowly in hardness until it merges with the unchanged core.

Carbon-aluminum with or without molybdenum gives a nitrided hardness of 1,000 Vickers Pyramid Number. When chromium is added, the elements combine to form a nitride case the hardness of which may reach 1,200 Vickers Pyramid Number. The hardness falls off rather rapidly and the case mergence with core is rather sudden. The addition of molybdenum improves nitrogen diffusion in carbon-aluminum steels and reduces the embrittling effect.

Steels specifically alloyed for nitrogen hardening should be fully treated to give the optimum mechanical properties before final machining to shape and size. When finally machined in the heat-treated condition there may be strains in the surface layers. Since strains mean that locked up stresses will be released during the comparatively long process of nitriding, it is advisable that the steel be stabilized beforehand to avoid warping and distortion. A recommended treatment is to soak at a temperature of 30 to 50 C above the particular nitriding temperature.

Parts that undergo heavy machining cuts, and are thereby strained, should be stabilized at the appropriate temperature before final grinding.

When machining to very close limits as for press or force fits, the growth in size caused by nitriding should be considered. Growth is related to the time and temperature of the process, but a reliable estimate may be based on case depth. Under normal conditions, the dimensional increase is 0.002 in. per 0.030 in. depth of case. A case depth of about 0.030 in. is the maximum produced commercially, it requires a treatment of about 80 to 100 hours.

When specifying case depths for nitrided work, some thought should be given to the time required to produce the case. Up to about 0.02 in. depth the time penetration curve is almost linear, Fig. 1, that is, 10 hr treatment will produce a case depth of 0.005 in., 20 hr produced 0.010 in. of case, 50 hr. produces about 0.021 in., but 100 hr produces rather less time than 0.030 in. depth of case. It is advantageous, therefore, to confine the case depth to the lower limits where the permissible amount of wear is closely limited.

The curves in Fig. 2 indicate the relationship between depth of case and hardness values for five grades of nitralloy steels. These curves are based on full time treatment at temperatures appropriate to each other.

All carbon steels that are hardened, no matter by what process, will begin to soften when exposed to temperatures above 200 C. Nitrided steels remain stable when exposed to temperatures as high as 500 C for periods up to one hour. Prolonged exposure at 500 C or higher does lead eventually to some loss of hardness. Thus the hardest grades retain a hardness value of 1,100 Vickers Pyramid Number for about one hour at 500 C; prolonging the period at the same temperature leads eventually to a fall in hardness to 800 Vickers Pyramid Number, and hardness remains constant thereafter.

In grades of initially lower hardness, the principal difference in properties derived from composition applies to the core. The mechanical properties of the core result from tempering at temperatures that are well above the nitriding temperature. These core properties are therefore unaffected by the process.

Surface hardness and surface finish when combined in a high degree afford valuable protection against fatigue failure. It is rare for fatigue failure to initiate on a nitrided surface. Where fatigue failures have occurred in nitrided steels, it has been found that the origin of fracture has been within the core.

The properties of the case in enhancing the endurance limit of the steel are advantageous only when the stress reversals are more or less normal to the hardened surface. In axial

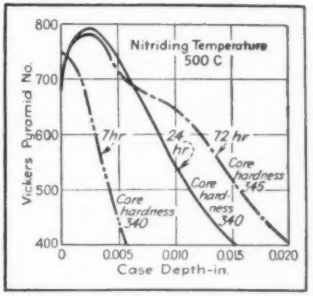


Fig. 1—Nitriding time and depth of case.

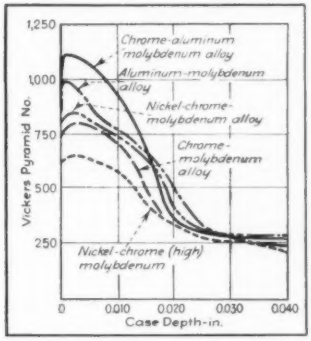


Fig. 2—Relation between depth of case and hardness.

loading, the high strength of the case plays only a secondary part in resisting the alternate compressive and tensile stresses and the endurance limit will be that of the core principally.

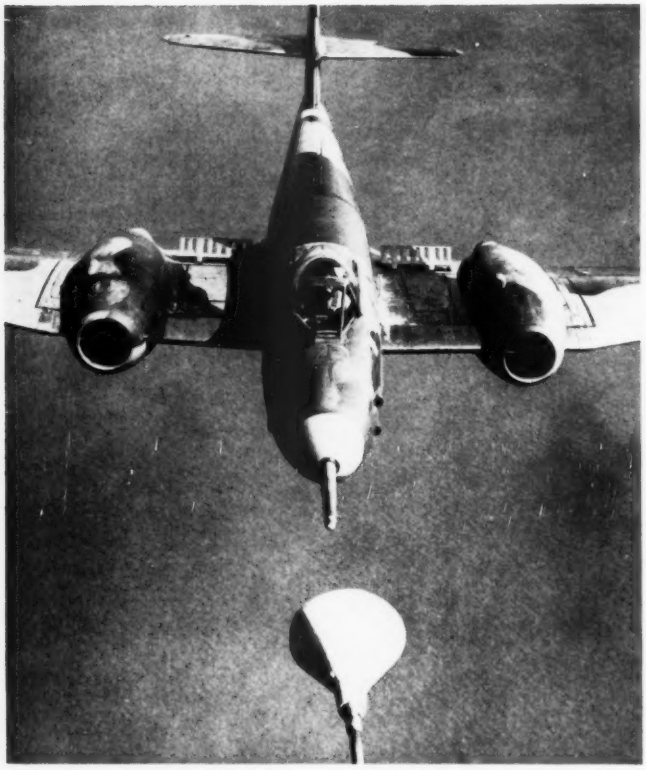
The properties of the case, however, extend beyond the high resistance to normal fatigue and enter the field of corrosion fatigue.

Nitrided steels are not truly within the stainless category, but the combination of high strength and surface hardness with fatigue and corrosion resisting properties make them almost ideal for many services.

Machining and usual fabrication methods as employed in high duty alloy steels are equally applicable to the majority of the nitriding steels.

Nitrided surfaces are capable of being operated together as journal and bearing under conditions of poor lubrication as in water pump spindle applications.

Steels alloyed for nitriding are weldable, but require the same precautions against cracking as are employed in the welding of ordinary high strength alloy steels.



Probe-nosed jet-fighter plane approaches automatic-coupling cone on refueling hose trailed from belly of tanker plane. Transfer of 300 gal takes about two minutes.

Midair Refueling of Jet Takes 90 Seconds

AMERICAN AIR FORCE OBSERVERS, as well as English aviation officials, are greatly impressed with the possibilities indicated by British experiments in air-refueling jet-powered fighter planes.

Recently, these experiments came to a dramatic climax when a Gloster Meteor was successfully refueled ten times from a Lancaster tanker during a continuous 12-hr flight over England's south coast. The flight set a new endurance record for jet aircraft and simulated a distance of approximately 3,600 miles.

Refuelings took place at about 6,000 ft with the two planes flying at about 190 mph. Each contact took between 1½ and 2 min and a total of about 2,500 gal of fuel was transferred during the experimental flight.

Technical Details

The Lancaster tanker trails a short length of flexible rubber hose that has a metal cone fitted to the end. The receiving fighter, which comes up close behind the tanker, carries a pencil-shaped hollow tube, like a probe, in its nose.

Maneuvering some 15 ft behind the tanker and just below its tail, the fighter pilot guides the probe forward into the cone and then accelerates momentarily until contact is made.

The clamping mechanism in the cone consists of three toggles that latch over an annular groove in the probe. A forward thrust of 5 lb is sufficient to seat these toggles and lock the cone firmly on the probe. A rubber ring in the cone's seat seals the joint.

When the joint is complete, the fighter pilot actuates a valve in the end of the probe, thereby opening the channel to his fuel tanks, and, at the same time, opening a valve in the cone, thus completing the circuit between the planes.

The hose is reeled out from the belly of the tanker from a spring-loaded drum affording automatic take-up of any slack in the hose. After contact is made, the fighter-pilot flies forward another four feet. At this point, a green light flashes automatically in the tanker's cockpit, signalling the refueling crew to switch on the fuel pumps.

Fuel flows from tanker to fighter at the rate of about 300 gpm until the fighter's tanks are full. Another device then switches off the tanker's pumps automatically.

Breakaway is a simple matter. The fighter pilot eases back until the hose has been pulled out to its fixed limit —65 ft. Here the reel is automatically checked and the drum locked when two pawls fall into notches on the drum's hub.

The fighter plane then drops back still farther exerting a pull of 300 lb that is sufficient to break the toggle connection.

With paraffin fuel, the danger of fire is less than with gasoline. Flight Refueling technicians, designers of the complete system, say that they will probably introduce some form of flushing as a safety precaution. For this purpose, they favor the use of an inert gas like nitrogen as being non-corrosive and less soluble than carbon dioxide.

Sir Alan Cobham, chairman and managing director of Flight Refueling, predicts a great future for this new technique. Refueling of jet fighters in flight could mean greatly increased range on escort missions accompanying long-range bombers. It might also permit fighters to remain aloft for much longer periods in defending against invading bombers.

The noted English pioneer said that the technique could be used for simultaneous refueling of three fighters to be supplied from one tanker —probably with hose units trailed from the wing tips and the fuselage.

The nose probe configuration as on the Meteor would therefore not be the standard installation, as each type aircraft would call for a special arrangement.

Work is already progressing on a system to allow refueling at 600 gpm, thereby cutting down actual contact time between tanker and receiver.

Krypton and Xenon Gases Commercially Available

MANY DIVERSIFIED PRODUCTS and processes will be improved by using krypton and xenon, now that these rare gases are available in commercial quantities at reduced prices.

Krypton occurs in the atmosphere as one part in one million, xenon one part in twelve million, and the separation and purification have presented complicated problems up until recently.

The inertness of krypton, xenon and the other rare gases makes them superior to nitrogen for certain purposes, since nitrogen, although considered inert, will combine with many elements at elevated temperatures.

Comparing krypton and xenon to argon, the former have the advantages of lower thermal conductivity, lower electrical resistance and lower ionizing potentials. Argon is now used in ionization chambers for tracking cosmic rays, an application where krypton and xenon hold promise of being superior.

Xenon has replaced mercury vapor in certain thyratrons and vacuum tubes. Unlike mercury, xenon will not condense at low atmospheric temperatures, and has electrical properties similar to mercury vapor.

Electronic Color Video Adapted for Present Sets

PERFECTION of an all-electronic color television system "completely compatible" with the present black and white video method has been announced by the Radio Corporation of America in a written statement to the Federal Communications Commission in Washington.

The company said its system would not make present sets obsolete. Color programs could be received on present sets in black and white without any modification or in color with the use of an adapter. New receivers would be made to take the transmissions directly in color.

It has been generally assumed in the industry that the F.C.C. has been awaiting the perfection of an all-electronic color system. The Commission turned down the Columbia Broadcasting System's "mechanical" method more than two years ago. This system uses revolving filters in the camera and viewing screen to achieve the color effect, whereas the R.C.A. method produces the color without such mechanisms.

The new system produces three signals, one each for green, red and blue. Following this, the signals are rapidly sampled electronically in time order for each color and then combined. The resulting single-channel signal requires a total modulation band width of four megacycles.

At the receiver end, the radio and intermediate frequency circuits are the same as for a current black-and-white receiver. The video signal is then fed from these circuits to an electronic device that is the inverse of the signal sampler at the transmitter. This restores the three-color signal channels of green, red and blue, and feeds them in simultaneous fashion to a three-color picture reproducing system to be viewed as a single picture.

Color Television Aids Study of Ram Jets

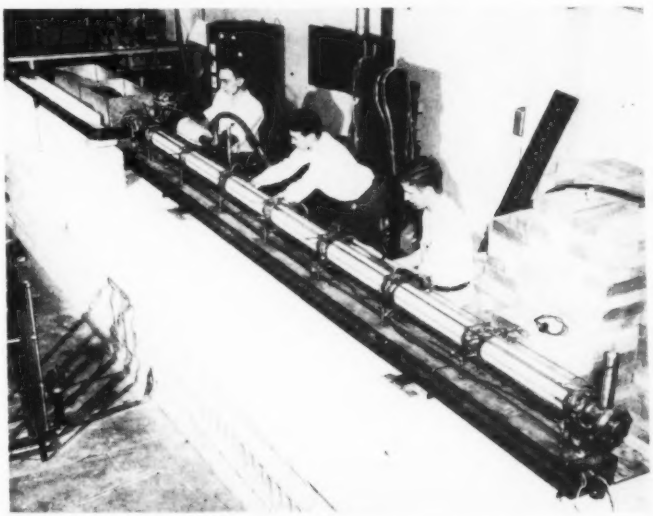
TESTS of a new industrial use for color television—remote observation of ramjet engine tests—have proved the promise of the application. The equipment was developed by Smith,

Linear Atom Smasher Installed at Stanford

THE FIRST 15-FT SECTION of a linear electron accelerator, recently installed in Stanford University's Microwave Laboratory, is expected to produce 70 to 80 million electron volts. When extended to its full length of 160 ft, the accelerator will produce close to a billion electron volts.

A high-power vacuum tube has been built and operated at an output adequate to power the completed accelerator. Several such tubes will generate power for the accelerator, operating in pulses of about 1/1,000,000th sec with a 1/60 sec "rest" period. Electrons will travel this microwave at a speed approaching that of light.

Attainment of the billion-volt goal will inaugurate a new method for studying properties of both the electron and the proton and possibly the neutron. The accelerator also will make possible a check of the "shower theory," based on the phenomenon that particularly energetic particles produce bursts of atomic particles and radiation when they collide.



First 15-ft section of linear atom smasher at Stanford University. Ultimate length will be 160 ft. Concrete blocks act as shield against radio-activity.

Kline and French Laboratories and the tests were conducted at the Wright Aeronautical Corporation, Wood-Ridge, N. J., under the direction of Dr. Peter Goldmark of the Columbia Broadcasting System.

As in all combustion research work, flame color is an index to combustion performance. In the ramjet engine undergoing development at Wright under Air Force Contract, color television enables engineers to project these color changes to a safe and comfortable observation room any desired distance from the scene of the tests through the use of a coaxial cable.

Principal advantage of this use of television is safety for the technical crew since the exhaust temperature reaches as high as 3,000 F and combustion pressures as high as 20 atmospheres are developed. The vibration and noise are intense in the test cell. The television camera does away with all of these dangers and transmits the flame colors to an observation room.

Ultimate objective of the program is the location of the television camera against a quartz window in the side of the ramjet engine to permit operation of the internal operation of compression, fuel mixing, combustion and exhaust gas expansion. Television has been used industrially before but this is the first application of color television to scientific research.

Automatic Plotting Board Will Simplify Navigation

A TINY SHIP sailing a dry sea and automatically reproducing in miniature the maneuvers of a real ship miles away is the latest development for precise marine navigation and hydrographic survey operations. The tiny ship is part of a new device known as a Raydist plotting board. The dry sea on which the tiny ship sails is in reality a map that shows the coastline, harbors, rivers and channels as well as sandbars and reefs.

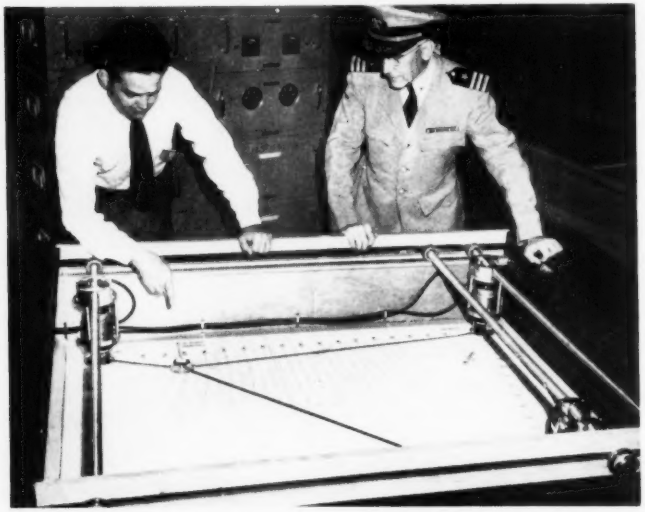
In the operation of the Raydist System, a small radio transmitter installed on the full-size ship sends a signal to several shore receivers that pin point the exact location of the ship. These receivers in turn transmit their data to servo mechanisms at the plotting board. Flexible steel tapes link the servos to the miniature ship and pull it along the map while a recording pen attached to the model makes a continuous plot of the course.

By watching the model maneuvering on the chart, an observer on shore can follow the exact course of a ship miles away—at a distance of five miles, the board will show the position of a ship to within five feet of its actual position.

With the board installed on board ship, it is possible to safely navigate narrow, twisting channels under adverse weather conditions with precision and complete confidence. Tests have been conducted under conditions such as rain, snow and fog when optical measurements would not have been practical. In each case, ranges in excess of 100 miles have been realized with a hyperbolic Raydist system tracking ships at sea. The maximum radiated power for these tests was only 10 watts.

In addition to tracking ships, the Raydist systems and automatic plotting boards can be used for oil exploration, hydrographic surveys, charting of rivers and channels and general air navigation.

This equipment has been developed by the Hastings Instrument Co. of Hampton, Virginia, for the U. S. Navy Bureau of Ships.



Automatic plotting board makes exact record of course followed by a ship 100 miles at sea. Plotting accuracy is to within one part in five thousand.

Baked Graphite Film Reduces Bearing Costs

A METHOD for applying a 0.00015 to 0.0005-in. stable film of graphite to metallic and non-metallic surfaces takes advantage of graphite's high-temperature resistance without requiring an oil-base suspension.

Process was developed primarily for the aircraft industry to fill the need for a stable lubricant at temperatures up to 2,000 F, but the method is fast being adapted to surfaces subject to galling at normal and sub-zero temperatures.

The graphite coating is sprayed or dipped on wearing surfaces and then baked at about 600 Fahrenheit. Resulting film is at first dull dark grey but it quickly burnishes after initial break-in. Life of the graphite coating depends on loads and bearing pressures, but tests have proved that surface wear life can be increased 3 to 10 times the normal on parts subject to high bearing and pounding loads.

In many machine elements, the graphite coating obviates the need for bushings, anti-friction bearings, plating or fluid lubrication formerly required to insure free operation. A low-cost bushing coupled with graphite coating of the pin has given service life equal to or better than that attained using higher-priced, anti-friction methods.

Washington Notes

Magnetic and Electric Fields Studied With "Electron Probe"

A new experimental technique using the electron as a probe to explore electric and magnetic fields of extremely small dimensions has been announced by the National Bureau of Standards. Test data are recorded in the form of photographs that show the direction and strength of magnetic forces about any small magnetized object.

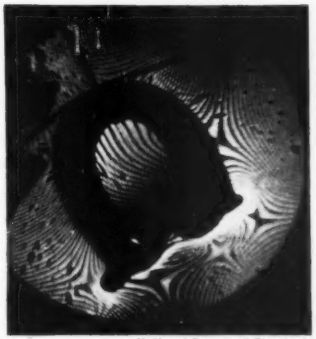
This so-called "electron-optical shadow method" is the result of a series of electron-microscope experiments conducted in connection with a study of magnetic recording wire used to feed mathematical problems to a high-speed electronic computing machine.

The electron microscope is first used to form an ordinary image of the magnetic object. A fine wire netting of nonmagnetic material is then placed slightly beyond the focus of the magnetic lens system of the microscope so that the mesh casts a magnified but sharp electron shadow on the screen. The shadow network is thus superimposed on the image of the magnetized object.

Some of the electrons that form the shadow image of the wire netting must pass through the field of the object and, in doing so, the electrons are deflected from their usual straight-line path by the magnetic forces. This movement causes a distortion and change of magnification in the shadow image of the network. The effect is most noticeable in the parts of the fluorescent screen that correspond to regions of strong magnetic force in the magnetic field. Thus a visual representation of the strength of the magnetic field at various points is obtained. These patterns can then be photographed.

A complete theoretical analysis of the shadow method has been made at the Bureau, and formulas have been worked out for calculating numerical values of the absolute field strength in the particular magnetic field being studied. These calculations are based on measurements of the distortion and magnification of the shadow image as it appears in the photograph. Such measurements can be made on extremely small or weak fields without altering or disturbing the field under study.

The new technique promises to be an important tool in the study of the ferromagnetic domains—groups of atoms that exist as small permanent magnets in iron, steel and other magnetic materials. A single crystal of cobalt having very large magnetic domains is being used in this study at the Bureau.



National Bureau of Standards

Shadowgraph shows pattern of magnetic field around a ½-in. horseshoe magnet.

The polarization of barium titanate and other high dielectric materials that are now widely used in the production of small-sized capacitors for radio, radar and television can also be investigated.

In the field of atomic physics, the Bureau is adapting the shadow method to the study of space-charge fields in several types of electron beam apparatus.

Another suggested application is in connection with wave guides—electronic plumbing that replaces wires, resistors, condensers and inductors in ultra-high frequency radio and radar. The Bureau pointed out that wave guide arrays often become so complicated that no geometry can be used to calculate radio energy distribution in the system. Through suitable auxiliary techniques, it appears that field strength at critical points, such as the elbows in these wave guide systems, can be explored with this electron-optical shadow method.

New Bill Would Admit 3,200 Foreign Technicians

A new immigration policy that will permit people of professional and trade skills to enter the United States has been approved by the House Judiciary Committee.

The policy is expressed in HR 3001, a bill that would set up a Foreign Skilled Personnel Board to pass on immigration of needed skilled aliens without regard to the particular position the applicant holds in the quota list of his native country. Under the bill, the extraordinary immigration would be limited to 3,200 persons a year and the special visas would be charged against the quota of the country from which the skilled person comes.

Here is how the law would work: A personnel board, made of the Secretaries of Defense, Labor, Interior, Commerce, Agriculture and the Attorney General, would act upon requests of other governmental agencies, both federal and state, as well as those of civic or private sponsors. Upon approval of the particular application, the immigrant would be permitted to enter the country on a visitor's visa. If, after a year, he is still working in his special field, his status would be made permanent.

Present regulations state that quota lists must be honored on a first come, first served basis. The specialists that have already entered the country for specific purposes are here only on a temporary basis, and cannot be eligible for permanent stay until their names have worked their way to the top of the master quota lists.

AEC Preparing to Release Data on Metals Techniques

Atomic Energy Commission has taken the first steps to make possible the release of atomic energy technological information to American industry. A trial program for examining, evaluating and declassifying selected technological information in the field of metallurgy has been inaugurated. If this program proves effective, the Commission can be expected to apply the procedure to other fields.

As the first move, a temporary advisory committee of representatives of professional societies and the business press has been set up. Chairman of the group is Sidney Kirkpatrick, McGraw-Hill Book Company, New York City.

This committee will recommend members for a small working group of engineers, representatives of professional societies and members of the business press in the field of metallurgy to study information that could be declassified without revealing the specific relevance of the material to the atomic energy program. Special attention will be given to data regarding pumps, blowers, valves and techniques of handling metals.

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Metal Finishing Process Information Sheets—V

GEORGE BLACK
Cooper Alloy Foundry Company

MAGNESIUM

MANODYZE: An electrochemical process for producing a protective and decorative magnesium-oxide-silicate film on the surface of magnesium and its alloys.

SOURCE: Hanson-Van Winkle-Munning Company, Matawan, N. J.

METHOD: Anodizing in strongly alkaline solution at elevated temperatures, using direct or alternating current.

APPLICATION: Suitable for all alloys of magnesium.

PROCEDURE:
1. Degrease.
2. Rinse.
3. Apply alkaline cleaner.
4. Rinse.
5. Apply acid cleaner.
6. Rinse.
7. Manodyze. Parts are made the anode in caustic soda-silicate solution for 15 to 30 min at 160 to 180 F. The a-c process requires 20 to 30 amp per sq ft; the d-c process requires 10 to 20 amperes per square foot.
8. Rinse.
9. Immerse in acid neutralizing dip.
10. Rinse.
11. Dry if parts are not to be dyed.
12. Seal with paints, lacquers, waxes, etc; or dye desired color.

CHARACTERISTICS:
1. The film is light to dark gray on most alloys if the a-c process is used; pale to dark green with d-c process, except on M alloys, where it is pale brown.
2. The film is insoluble in water and is attacked only very slowly by weak acids.
3. Salt spray resistance is high.
4. Abrasion resistance is excellent.
5. Dielectric strength is high.
6. The coating from the a-c process is very dense and compact. The film from the d-c process has greater depth and reveals some porosity. The d-c process is superior for dye application.
7. Thickness of 0.0002 to 0.0005 in. with the a-c process results in negligible build up in dimensions. Thickness of 0.0004 in. to 0.001 in. with the d-c process results in build up in dimensions equal to 40 percent of coating thickness.

ANODIZING MAGNESIUM: An electrochemical process for producing a hard white crystalline coating on the surface of magnesium and its alloys.

SOURCE: Turco Products, Inc., Los Angeles, California.

METHOD: Anodizing in a saturated solution of sodium carbonate and water maintained at elevated temperatures.

APPLICATION: Suitable for most alloys of magnesium, but not suitable for M alloys.

PROCEDURE:
1. Degrease.
2. Rinse.
3. Alkaline cleaner.
4. Rinse.
5. Anodize in hot saturated solution of sodium carbonate using high voltage (110 to 120). Temperature of the bath is maintained between 190 and 207 F and treatment time ranges for ½ to 1 hour.

CHARACTERISTICS:
1. Coating is hard, white and crystalline.
2. Dimensional increase of about 0.0005 in. is effected.
3. Tests have shown that magnesium so anodized possesses excellent abrasion resistance.
4. Corrosion resistance of coating is extremely high.
5. Coating provides excellent base for paint.

CHROME PICKLE: A non-electrolytic process for producing a protective coating on magnesium and its alloys.

SOURCE: Dow Chemical Company, Midland, Michigan; American Magnesium Corporation, Cleveland, Ohio.

METHOD: Simple immersion at room temperature. This may be followed by boiling in sealing solution if greater corrosion protection is required.

APPLICATION: Satisfactory for short time protection of all alloys of magnesium not high in manganese. Not satisfactory for machined parts with close tolerances.

PROCEDURE:
1. Degrease.
2. Rinse.
3. Immerse in alkaline cleaner.
4. Rinse.
5. Chrome pickle. Immerse for ½ to 2 min in solution of sodium dichromate and nitric acid or solution of chromic and nitric acids.
6. Rinse.
7. If superior corrosion resistance is required, seal by boiling for 30 min in potassium or sodium dichromate solution to which magnesium or calcium fluoride has been added. Then rinse.
8. Dry.

CHARACTERISTICS:
1. Color of treated surface varies from red to yellow iridescence.
2. Unsealed coating gives short time protection against tarnish and corrosion during handling and storage.
3. Sealed coating gives protection from severe handling and moderately extended storage periods.
4. Treated surface forms suitable base for paint. When sealed coating is protected with organic finishes, it is highly corrosion resistant.
5. Treatment will not effect bronze, steel or cadmium inserts. Galvanized and brass inserts will be etched.

ACID DICHROMATE: A non-electrolytic process for producing a protective coating on the surface of magnesium and its alloys.

SOURCE: Dow Chemical Company, Midland, Michigan; American Magnesium Corporation, Cleveland, Ohio.

METHOD: Simple immersion in boiling dichromate solution, preceded by hydrofluoric acid dip.

APPLICATION: Suitable for all alloys of magnesium except those high in manganese. Satisfactory for machined parts with close tolerances.

PROCEDURE:
1. Degrease.
2. Rinse.
3. Apply alkaline cleaner.
4. Rinse.
5. Immerse for 5 min in 15 to 20 percent solution of hydrofluoric acid, maintained between 70 and 90 degrees Fahrenheit.
6. Rinse.
7. Boil for 45 min in 10 to 15 percent solution of sodium dichromate.
8. Rinse.
9. Dry.

CHARACTERISTICS:
1. Properly treated parts will vary in color from brown to black depending upon the alloy.
2. The coating produced is relatively soft and must be followed immediately by prescribed paint coats.
3. The film provides an excellent base for paint.
4. The process is simple and easy to control in production work.
5. There is no appreciable build up in dimensions.
6. Magnesium parts with brass, bronze, steel, or cadmium plated parts can be treated satisfactorily. A 5 percent acid fluoride bath is recommended in place of the hydrofluoric acid solution when material bearing these inserts is being treated.

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Belleville Spring Design Charts—VI

LESLIE W. JONES
Corning Glass Works

For description of chart construction see Product Engineering, January 1949, page 161.

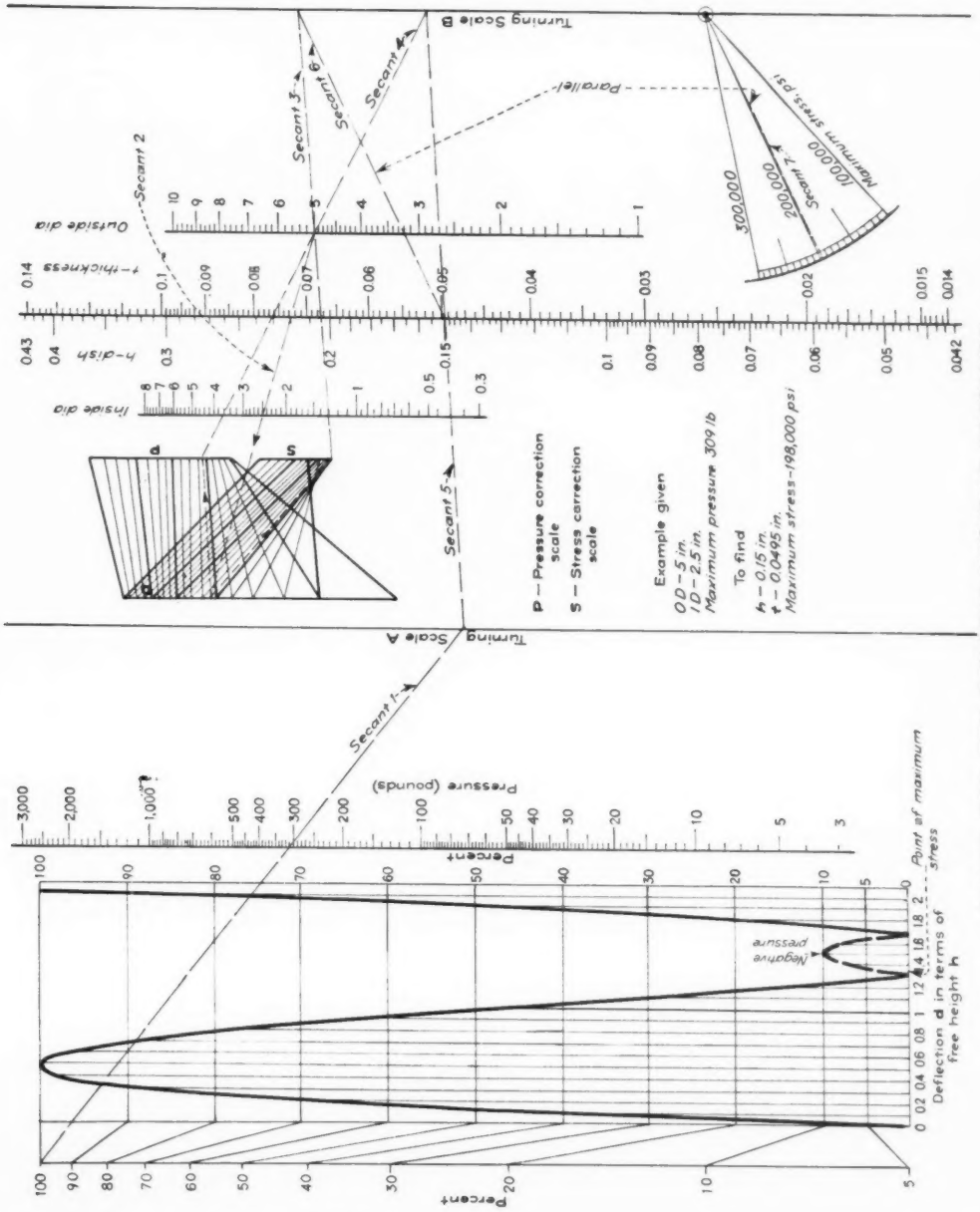


CHART FOR TEN PERCENT NEGATIVE PRESSURE

This cost/weight saving was the happy experience of a farm equipment manufacturer who redesigned a portable grain elevator, replacing angles and channels with 1 ¾" and 2" O. D. Armco Steel Tubing.

The $9.44 saving on each elevator is in material costs alone. Besides this saving, the elevator is fabricated and assembled easier and quicker than when heavy angles were used.

Dealers and their customers are pleased, too. They like the "new look"—the improved appearance of round Armco Tubing compared with bulky angles. They also like the lighter weight without loss of strength. (Total weight of the tubing is 128 pounds; the angles weighed 289 pounds.)

This is a typical example of the savings in cost and weight that are possible when light structural products are redesigned with Armco Steel Tubing.

The beauty of it is that this electric resistance-welded mechanical tubing can be adapted readily to almost any fabricating pattern you require. Made-to-order special or standard shapes help eliminate or greatly reduce many costly fabricating operations.

If you believe the design of **your** products can be adapted to the economical use of Armco Steel Tubing, just mail the handy coupon. Armco engineers will be glad to work with you to determine the possibilities of tubing for your requirements. Armco Steel Corporation, 3929 Curtis Street, Middletown, Ohio.

Export: The Armco International Corporation

ARMCO STEEL CORPORATION

ARMCO

SEND MORE DATA ON ARMCO TUBING

WE MANUFACTURE _____

NAME _____

FIRM NAME _____

STREET _____

CITY _____ **ZONE** ____ **STATE** _____

Belleville Spring Design (continued)

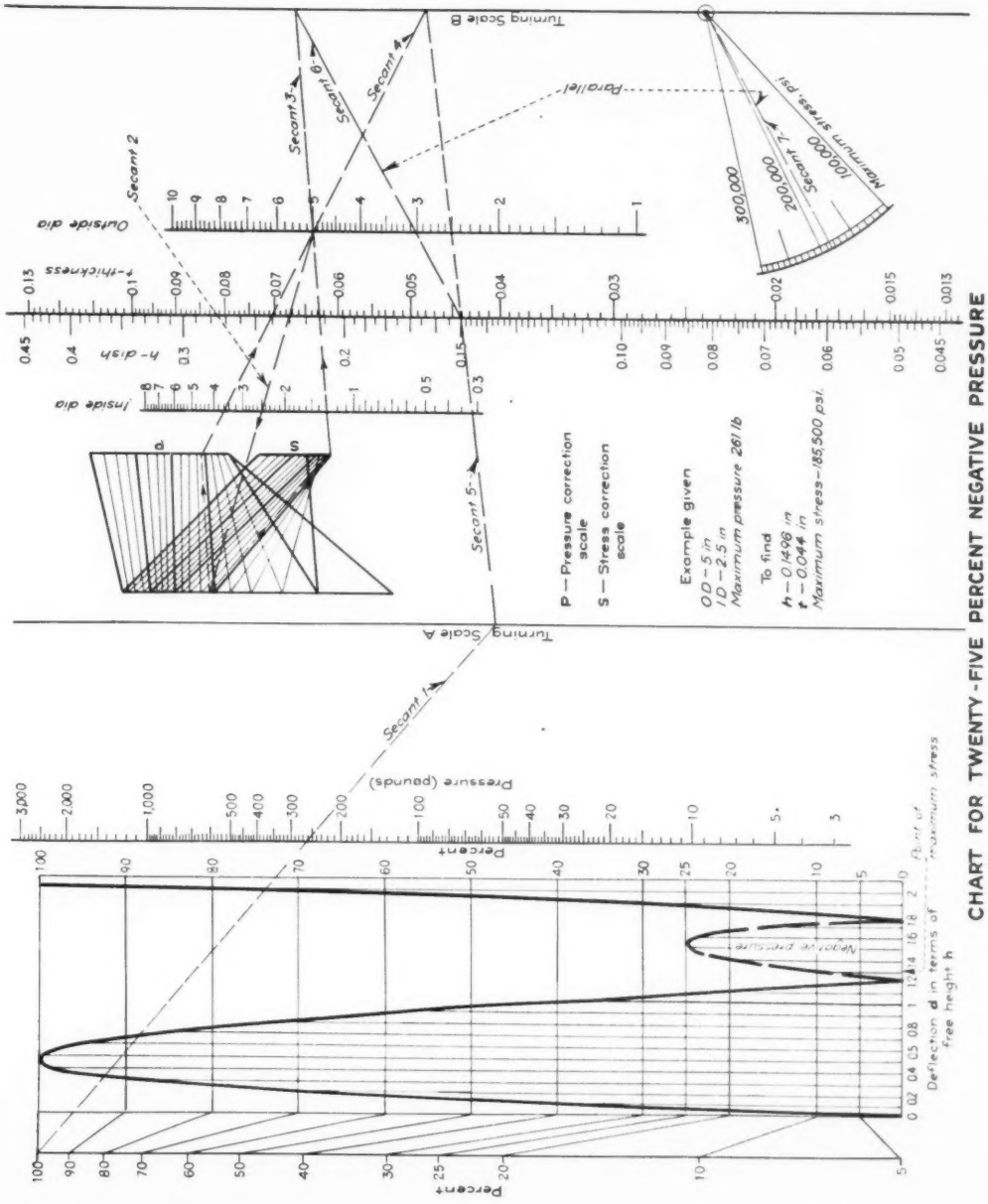
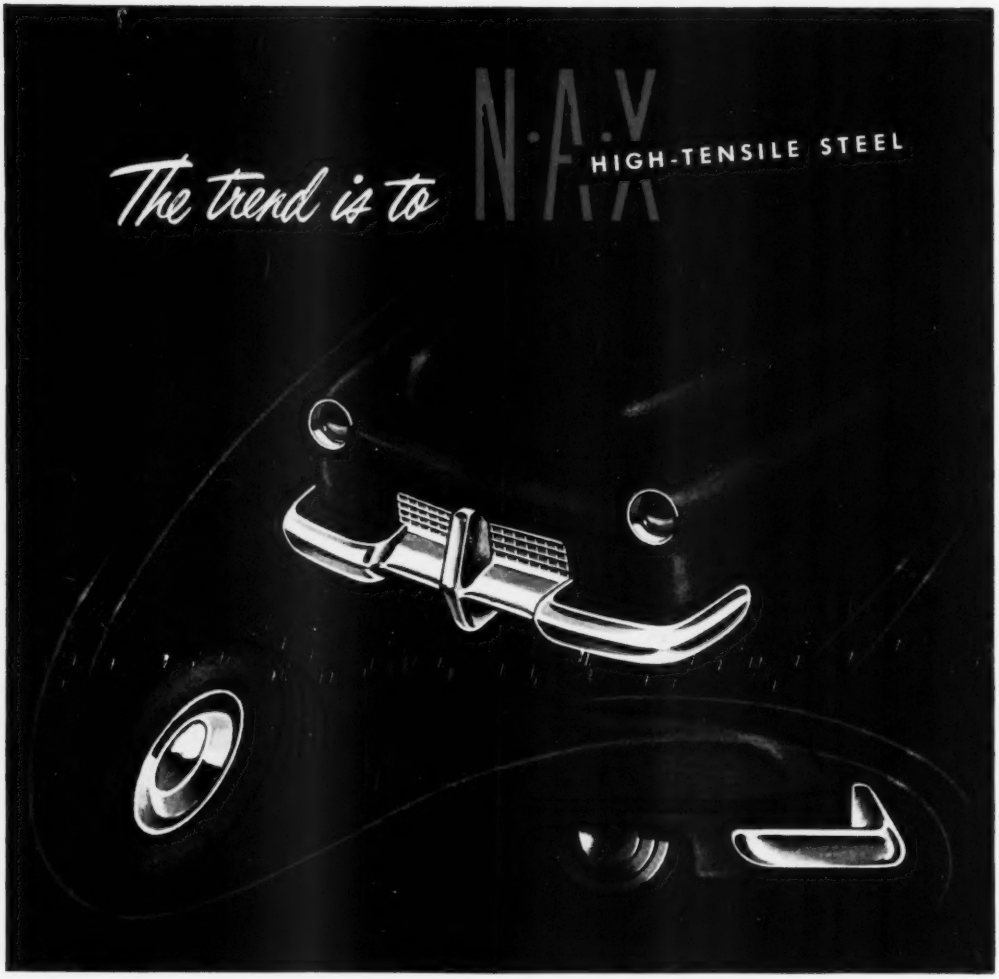


CHART FOR TWENTY-FIVE PERCENT NEGATIVE PRESSURE



Since 1940, when Great Lakes Steel pioneered the application of high-tensile, low-alloy steel to cold-stamped automobile bumpers, there has been a growing trend to N-A-X HIGH-TENSILE steel in the automobile industry.

Today, every car manufacturer is using the inherent better properties of N-A-X HIGH-TENSILE steel for some part of his automobile.

Bumpers and grilles—hoods and fenders—body panels and deck lids—frames and bracings—wheels and hub caps represent a few of many applications of N-A-X HIGH-TENSILE steel to the modern car.

MAKE A TON OF SHEET STEEL GO FARTHER Specify— N·A·X HIGH-TENSILE STEEL

N-A-X HIGH-TENSILE MEETS ALL REQUIREMENTS OF S.A.E. 950

GREAT LAKES STEEL CORPORATION N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN *Unit of National Steel Corporation*

NEW MATERIALS AND PARTS

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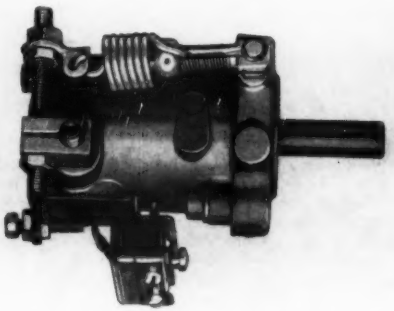


Centrifugal Governor

Pierce Governor Co., 916 Sixth St., Anderson, Ind.

Particularly adaptable in situations where corrective measures must be taken before putting "runaway" equipment back in operation, this micro-switch governor turns off electrically energized equipment when predetermined speeds are exceeded. The micro-switch is available on both the direct drive and the cable driven centrifugal governors. The cable driven governor features a flexible drive shaft with pulley, gear and tachometer adaptors. These permit power take-off from remote sources. Pierce governors are also available with a mercury arc switch which performs the same functions as the micro-switch. They are designed especially for operations involving fire hazards, such as grain elevators, mines, power boats or in the presence of explosive fumes.

Plasticized Rubber Compound

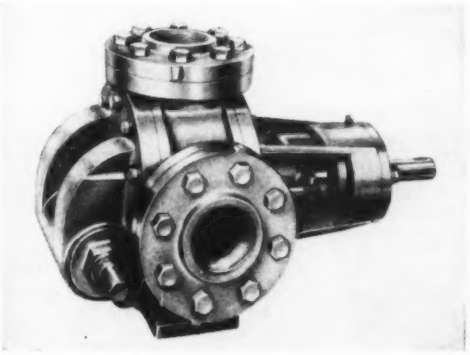
The Stalwart Rubber Co., 166 Northfield Rd., Bedford, Ohio

This versatile material is recommended for use in fabrication of tool handles, foot treadles, mallet heads, toys, vacuum cleaner accessories, and other such items. It was designed for applications which require an extremely durable wear-resistant rubber. Stallite 869, as it is called, also can be used to replace certain types of metal parts. It has a durometer hardness of 95 and tensile strength of 1,854 psi. Material will withstand temperatures ranging from 0 to 250 F. Its main features are resilience, high impact strength, corrosion resistance, and light weight. Secondary drilling and machining operations can be performed on parts fabricated from it. It can be painted for decorative applications.

Butane and Propane Pump

The Yale & Towne Mfg. Co., 200 Henry St., Stamford, Conn.

Another of a series of Tri-Rotor pumps, this unit operates in equalized systems with differential pressure up to 50 psi. When the rotor revolves, the offset relation of bearing pin to rotor shaft imparts reciprocating motion to the piston and shuttle. Thus, the advantages of both rotary and piston action combine to give positive displacement. Since rotor openings receive and discharge over 90 degrees, four pumping strokes overlap, and as the areas of shuttle and piston are equal, a smooth flow is discharged. This pump is furnished with 2½ in. flanged connections and with solid or integral dash-pot relief type head. It delivers 90 gpm at 615 rpm, and

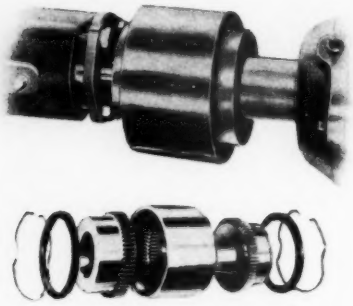


can be supplied for truck installation or for installation as a mounted unit with flexible coupling (gear motor) gear reduction or V-belt drive assembly.

Gear Coupling

Sier-Bath Gear & Pump Co., Inc., North Bergen, N. J.

This new gear coupling has less than half the parts used in most conventional gear couplings. Since there are no bolts the sleeve may be removed in a matter of seconds. Forged high carbon steel construction and full width



machined teeth give maximum strength and perfect alignment without excessive backlash. The snugly fitting Neoprene seal and the reinforcing garter spring maintain constant closure against slight depressions or unevenness of the shaft surfaces. These couplings are available in $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ in. sizes. Larger sizes are built to customer specifications.

Electric Control Wire

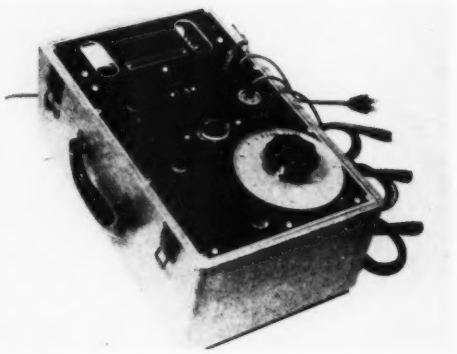
Midwest Automatic Control Co., 510 Third St., Des Moines, Iowa

The use of numbers on this wire for electric controls increases the ease and accuracy of installation and maintenance. Called "Magic Wire," each wire has its code number imprinted in bright red on every inch of yellow insulation. Numerals do not wash or wear off or become discolored with age. No limit is set on the number of different numerals available. Wire is especially useful for automatic control systems, printing presses, aircraft, signal devices, and other such controls. It is available in No. 16 solid wire with plastic insulations.

Resistance Meter

Crown Industrial Products Co., 1311 W. 69th St., Chicago 36, Ill.

This unit is designed for measuring insulation resistance in both low and extremely high ranges. The indicator used with the bridge is a 6E5 electron ray tube. This tube, used with an adjusting circuit and a balance switch, replaces the usual galvonometer and sensitivity of the bridge does not suffer. An external guard circuit guards specimens under test so that leakage across paths other

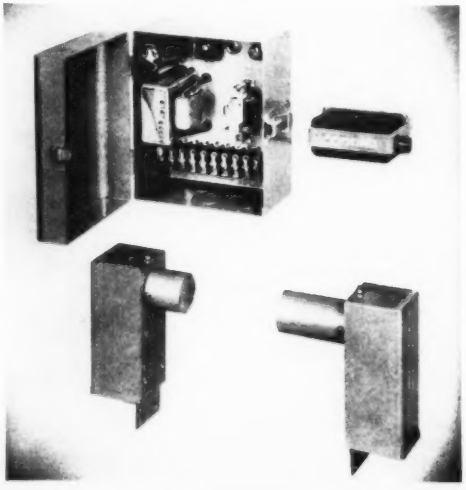


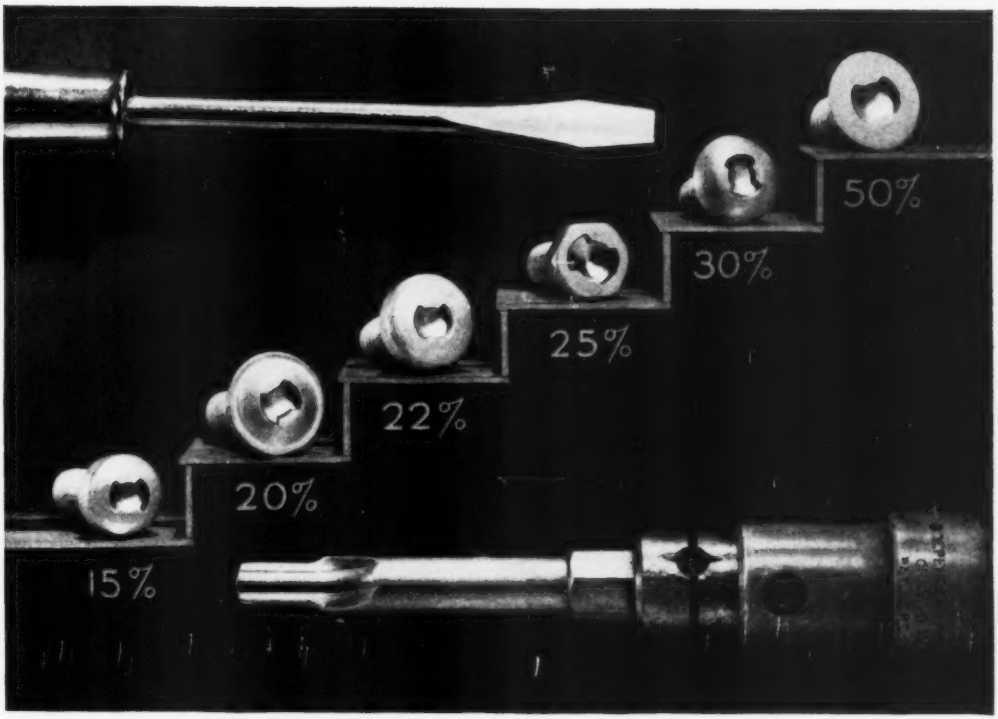
than the one under test is returned to a point in the bridge where it has no effect upon test measurement. Accuracy of the unit is independent of power line voltage variations. The meter has a range from 1,000 ohms to 100,000 megohms. Three test voltages are used: 10, 100 and 500 v. d-c. Unit operates on 115-volt, 60-cycle current.

Photoelectric Counter

De-Tec-Tronic Laboratories, Inc., 1227 N. Clark St., Chicago 10, Ill.

Counting closely spaced cans, box cases, bubbles or drops of liquid, or selective counting by height or weight, and many other counting applications are possible with this new compact photo electric counter. It consists of four units: an amplifier relay, an extension light source, a photo electric cell housing, and a six digit knob reset counter. Counting up to 600 units per minute, it registers up to 999,999 before returning to zero. The size of counter is $3\frac{3}{4}$ by $2\frac{1}{2}$ by $1\frac{1}{2}$ inches. An amplifier control relay can be installed at any desired location, remote from the point of count. A complete amplifier relay is





The Percentage Is All in Your Favor

These production increases are from the records of assembly lines where change-over was made from *other* types of *recessed head screws* to CLUTCH HEAD

HERE'S HOW CLUTCH HEAD PAYS OFF IN GAINS AND SAVINGS

High visibility of the recess cancels out slow-down hesitation . . . confident operators logically drive more screws.
Center Pivot entry prevents driver canting, insures straight driving . . . saves cost and delay of "fixing" burred or chewed-up heads.
Non-tapered driving engagement reduces skid hazard to zero . . . protects manpower and saves costly damage to materials.
All-square contact means no "ride-out" (as set up by tapered driving) . . . no fatiguing end pressure needed to combat "bucking."
The CLUTCH HEAD Lock-On hurdles "fumble spots" on the line . . . unites screw and bit as a unit for one-handed reaching and driving.
The rugged Type "A" Assembly Bit for unmatched tool economy . . . drives up to 214,000 screws non-stop on a high torque job.
Check the extra profit stemming from this steady production flow . . . no time-wasting stoppages for frequent tool changing.
Repeatable reconditioning multiplies the life of this bit . . . only a 60-second application of the end surface to a grinding wheel.
This simple operation restores original efficiency, *time and time again* . . . no expense or bother of back-to-the-factory shipments.
Consider the value of simplified field service . . . with a recess basically designed for common screwdriver operation.
Your service men and customers save time on field adjustments . . . any flat blade reasonably accurate in width will do.

These exclusive time and money-saving features are fully described and illustrated in the new CLUTCH HEAD *brochure. Send for your copy, mentioning the sizes and types of screws, standard or special, that interest you . . . to come by mail and without obligation.*

CLUTCH HEAD SCREWS

UNITED SCREW AND BOLT CORPORATION

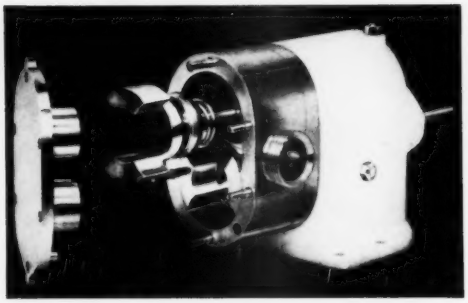
CLEVELAND 2 CHICAGO 8 NEW YORK 7

housed in an 18-gage steel case with hinged cover, 6¾ in. high 5¼ in. wide and 4½ in. deep. The unit is designed for 110/125 v, a-c and 50/60 cycles. Power consumption is 70 watts. The finish is grey hammerloid.

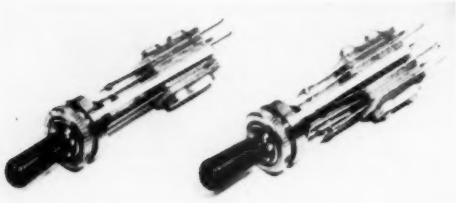
Sanitary Pump

Waterous Co., 80 E. *Filmore Ave., St. Paul, Minn.*

Designed specifically for the food processing and chemical industries, these units do not contaminate the pumped fluid. All interior parts are stainless steel, the rotor and shaft are one piece, and all internal threads, springs, etc. have been eliminated. Parts which may be exposed



to the pumped fluids are made for quick disassembly and easy cleaning. Pump maintenance, "product plug" and leakage are minimized by the use of a non-rotating seal and the placing of seal springs outside the pumping chamber. Available in capacities from 1 to 125 gpm, with speeds from 50 to 600 rpm, the pumps have 1 to 2½ in. port connections.



Small Lever Switch

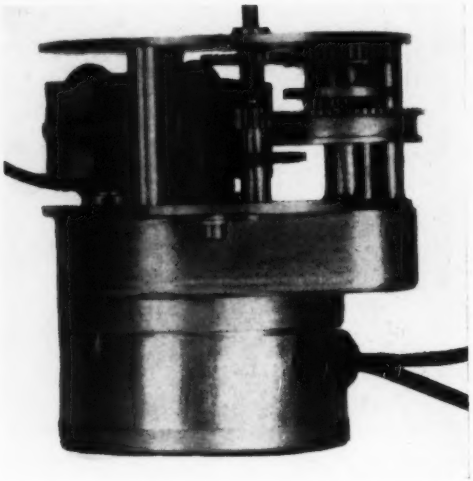
Switchcraft, Inc., 1328 *N. Halstead St., Chicago* 22, *Ill.*

Features of telephone type switches are included in this small lever switch. It is particularly adaptable to all types of low power switching applications such as money meters, sound systems, and inter-communication systems. Less than one-half of the mounting space normally required for a lever switch is needed and only a single hole mounting is used. Switch comes for standard circuits in both two or three position actuators, either locking or non-locking. Silver contacts, rated at 3 amps, 120 v, a-c, non-inductive load are standard. Also available are silver contacts for high voltages and palladium contacts for low currents at low voltages. Product is called the "Lev-R" switch.

Small Synchronous Motor

The R. W. Cramer Co., Inc., Centerbrook, Conn.

Designed for timing, recording, indicating, and switching applications which require an accurate reset operation, the Type SXC synchronous motor has a differential clutch mechanism. The clutch unit consists of a differential and an internal tooth planetary gear system with the sun gear directly coupled to the motor and the planet

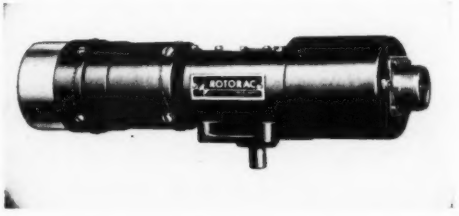


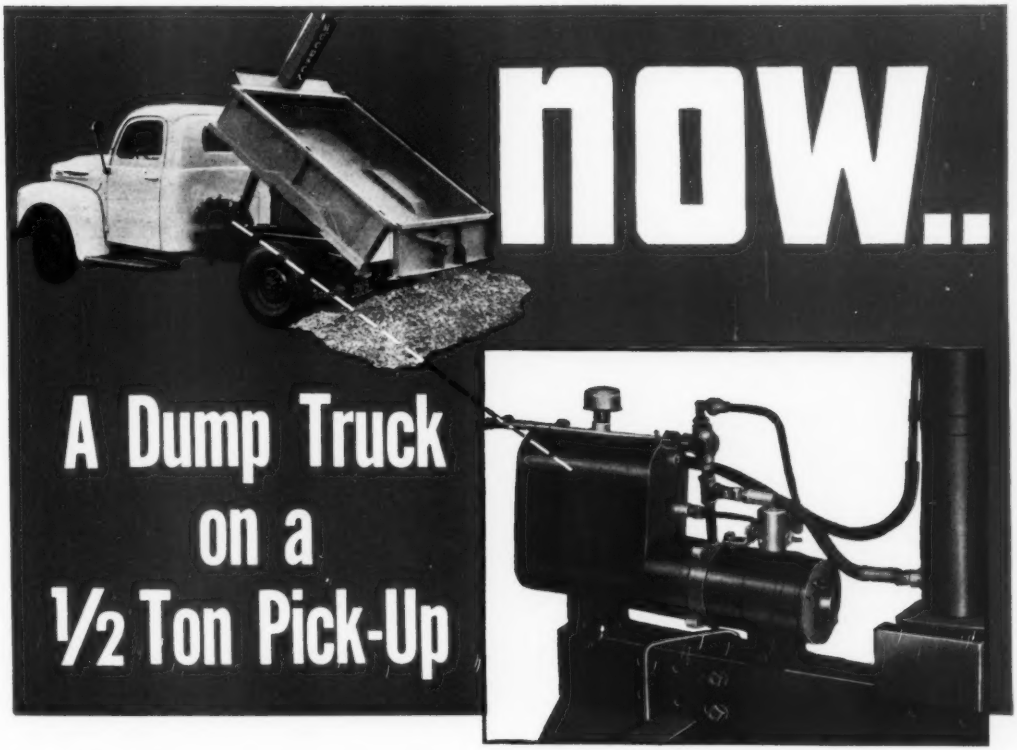
gears to the output. The sun and plant gears are locked by energizing an electro-magnet. Deenergizing the magnet breaks the driving couple. Positive action is assured with no slipping or wear. Thirty-nine output speeds are available—from 15 to ¼ rpm. The size of the unit is approximately 2 1/16 by 3 in. It can also be furnished with a reverse clutch that engages when the magnet is deenergized.

Rotary Actuator

Airborne Accessories Corp., 25 *Montgomery St., Hillside* 5, *N. J.*

Originally developed for intermittent duty aircraft applications, newly redesigned "Rotorac" has many industrial applications. Essentially, it is a reversible geared motor, magnetically braked, with a right angle power take off and with a provision for controlling the number of shaft revolutions between desired limits. The unit has a 26 v d-c explosion proof reversible motor, a magnetic brake for quick stopping and to prevent creep, and





This Pesco Power Package Makes It Possible!

Woodson Products, Detroit manufacturer of specialized truck bodies, realized the need for a light dump truck. For farmers, coal dealers, contractors and light haulers it would prove a real time and money saver. But how to lift the dump body was the stopper. Light trucks have no power take-off. Therefore, the unit would have to supply its own. What's more, it would have to be light, compact, inexpensive to operate, foolproof to use.

Woodson found the answer in the Pesco electric motor-driven Power Package. Compact, its motor, hydraulic pump, reservoir, check and relief valves are built into a single unit. Powered with a battery-operated, 6-volt, d.c. motor, it will raise a 1-TON load in 40 seconds, using only 85 amps—1/100 of the battery's capacity. It is available in ½-ton to 2-ton capacity.

It is push-button controlled and it will raise, lower or hold the dump body in any position. And Pesco's exclusive "Pressure Loading" feature assures the highest operating efficiency, at all times.

Fully proved in use. During the war, thousands of Pesco Power Packages raised and lowered the landing gears of thousands of bombers, where absolute, trouble-free dependability was a *must!*

Whether you make dump trucks or farm machines, hydraulic presses or machine tools, Pesco Power Packages, Hydraulic Pumps, Motors or Control Valves will help you get more efficient operation, more positive control, easier sales. Write today for more information.

★ **DESIGN ENGINEERS:** Pesco Power Packages are available for 6, 12, 24 and 33-volt, d.c. systems. With a capacity range from .7 gpm to 4.5 gpm, at 1000 p.s.i.

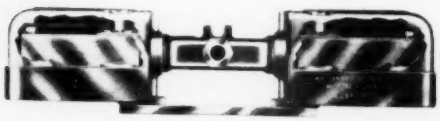
Pesco PRODUCTS DIVISION
BORG-WARNER CORPORATION
11610 Euclid Ave. - Cleveland 6, Ohio
MANUFACTURERS OF BW SUPERCHARGERS

a thermal overload protector, the latter being optional equipment. Weight is 1.9 lb, or 2 lb with an extra-power motor. Length is 9.27 in. without thermal protector.

Double Solenoid Air Valves

Valvair Corp., 454 Morgan Ave., Akron 11, Ohio

Double solenoid valves for air pressures of 0 to 125 psi are now available in sizes of $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$ inches. All are obtainable for 110, 220 and 440 volts in both 50-60 and 25 cycles. Valves have a one-piece bronze base for each solenoid with heavy and powerful solenoids for positive

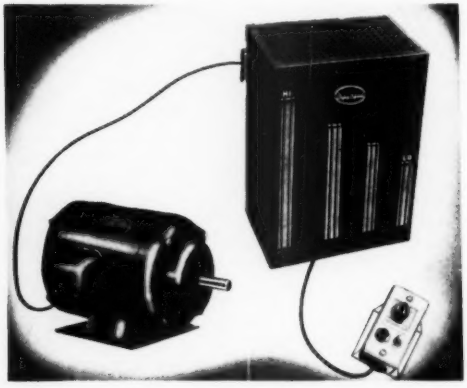


seating and cool operation. A heavy sheet metal cover supplies protection. Valves have shock-resisting clevis and clevis pin and "OU" type packer. Models include 2-way, 3-way and 4-way piped exhaust. All air handled by these valves must be first filtered and lubricated.

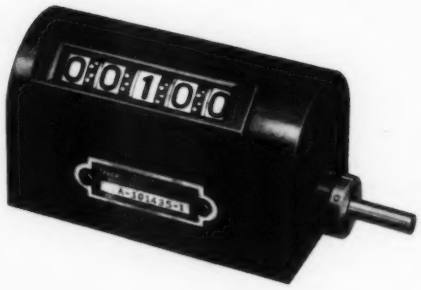
Electronic Motor Control Unit

The Brown-Brockmeyer Co., Dayton, Ohio

Particularly well suited to applications such as conveyors, lathes, mixers, paper-making machinery, and textile machinery is this remote, stepless speed adjustment and control for fractional horsepower motors. Any speed within a range greater than 20 to 1 (80-1,800 rpm) can be maintained constantly regardless of load changes. Torque is also maintained as a constant over the entire



speed range. Operator can adjust motor while at a considerable distance from it. Power from a full-wave gaseous rectifier is supplied to the armature and field of the motor. An idle switch on the control box can be used to turn motor on or off without changing or disturbing speed setting. The Dyna-Speed equipment is available in ratings of $\frac{1}{4}$ and $\frac{1}{2}$ horsepower.



Counting Device

Veeder-Root, Inc., Hartford, Conn.

Called the Duo-Cam Counter, this new device has been developed chiefly for use in size-grading operations, to count number of pieces graded, on can-closing machines and other similar uses. It can be obtained both as a revolution ratchet counter or as a ratchet-with-stops counter. The first type adds one count for each revolution of the drive shaft in either direction; the second adds one count for each oscillation of the lever through an angle of 30 degrees. Maximum recommended speed of the revolution type is 200 counts per minute, of the ratchet-with-stops type, 500 counts per minute. The counter is reset with a clock key. Overall dimensions are $5\frac{1}{2}$ by $2\frac{7}{16}$ by $2\frac{1}{8}$ inches. The dial has five figures.

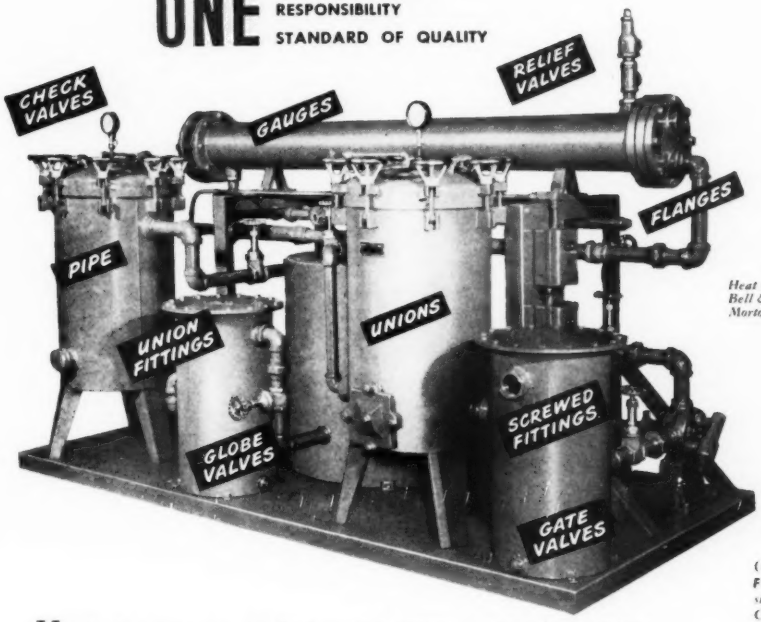
Precision Drafting Machine

L. G. Wright, Inc., Box 63CU, Cleveland 21, Ohio

Eliminating all obstructions along the top edge of the drawing area, the new Model D Wrigraph Drafting Machine mounts in the extreme right hand corner of the drawing board instead of the center or left corner as on most other machines. This new instrument permits free movement of the scales over the entire drawing areas without interference. Designed for the thousands of smaller drawings made in every organization, it is a portable unit for the individual use of technical men who want to carry a machine with them for use anywhere. The drawing area is 20 by 26 inches. The ma-

Short cut for machine designers ...Specify piping from CRANE

ONE SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



Heat Exchanger by Bell & Gossett Co., Morton Grove, Ill.

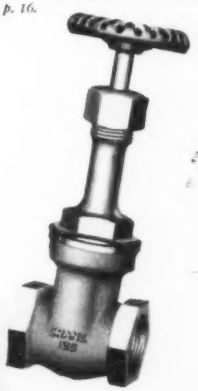
Here's the surest way to find . . . in a hurry . . . the valves, fittings, pipe and accessories called for by the design on your boards. Just consult your Crane Catalog. It gives you easy access to the world's most complete line of quality piping materials.

For This Heat Exchanger . . . as for any machine design . . . the broad Crane line is the **One Source of Supply** complete enough to simplify every piping procedure, from specification writing to assembling the finished product.

One Responsibility for piping materials simplifies ordering and storekeeping, too; assures better control of product assembly operations. And when your customers see "Crane" on piping equipment, it gives your product added value. For they know from experience that Crane Quality and **High Quality** are synonymous.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

(Below) **FOR GENERAL SERVICE** *on steam, water, oil or gas lines—Crane recommends 125-Pound Brass Gate Valves. Ruggedly constructed, proportioned to assure high safety factor against pressure, operating strains, expansion and contraction of piping. Shown here, No. 428 Gate with solid wedge disc; rising stem; screwed ends. Working pressures: 125 pounds steam; 200 W.O.G. Sizes: ¼ to 3 in. See your Crane Catalog, p. 16.*



EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

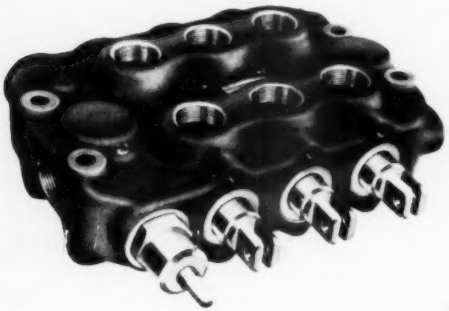
FOR EVERY PIPING SYSTEM

chine is easily fastened to any board or table. The ball-bearing precision drafter is accurately calibrated through eccentric adjustments built into the mechanism. Interchangeable engine-divided scales in all of the standard graduations are available. The lightweight protractor can be locked at any angle.

Hydraulic Control Valves

Hydraulic Equipment Co., 1100 *E. 222nd St., Cleveland* 17, *Ohio.*

New V-8 series oil-hydraulic control valves are for large volume oil-hydraulic systems, such as road-building, earth-moving machinery, heavy-duty industrial equipment, or



hydraulic presses. They will handle 80 gal of oil per min at pressures up to 1,000 psi. Models are available which will operate up to three single or double-acting hydraulic cylinders. Design features include a hollow-plunger construction with built-in check valves, and adjustable differential type relief valves.

Dielectric Material

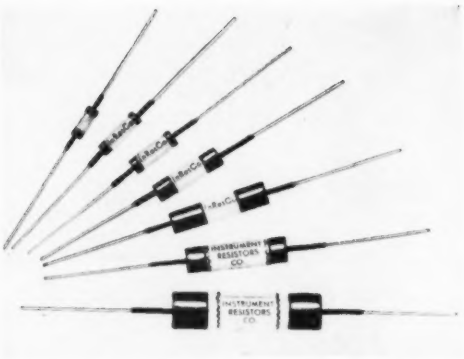
Bentley, Harris Mfg. Co., Conshohocken, Pa.

A new braided Fiberglas material in the form of tubing and sleeving has better physical and dielectric properties than the usual cotton or rayon-base insulation. Known as BH 649, the new material stands up under rough treatment such as knotting, twisting, or direct flame without insulation breakdown. Wire threading is made easier because the Fiberglas material cuts clean, without frayed ends. In tests the dielectric has withstood potting temperatures up to 450 F for one hour and a constant temperature to 220 F for 96 hours with no loss of dielectric strength or physical change. The megohms resistance is 50,000 when dry and 10,000 wet.

Midget Wire Wound Resistors

Instruments Resistors Co., 1036 *Commerce Ave., Union, N. J.*

Photograph shows a line of resistors designed for applications where space is at a minimum. Type IR resistors are wire wound to a standard tolerance of plus or minus 1 percent, and maintain this accuracy throughout their use. They withstand rough usage and intermittent overload. Available in seven sizes, their maximum resistance

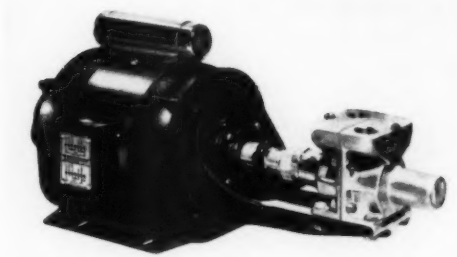


varies from 1,200 to 28,000 ohms with wattage ranging from $\frac{1}{8}$ to 5, and body lengths from $\frac{3}{8}$ to $1\frac{1}{2}$ inches. Resistors are moisture and fungus proof, and coated in Bakelite to eliminate heat shrinkage.

Gearless Pumps

Eco Engineering Co., 12 *New York Ave., Newark* 1, *N. J.*

These general utility close-coupled electric motor-driven gearless pump units are particularly adaptable for original equipment manufacturers desiring a compact unit. Models are available with $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$ in. ports. Units are designed to give suction lift ranging from simple suction circulation up to heavy duty against 150 psi. Motors

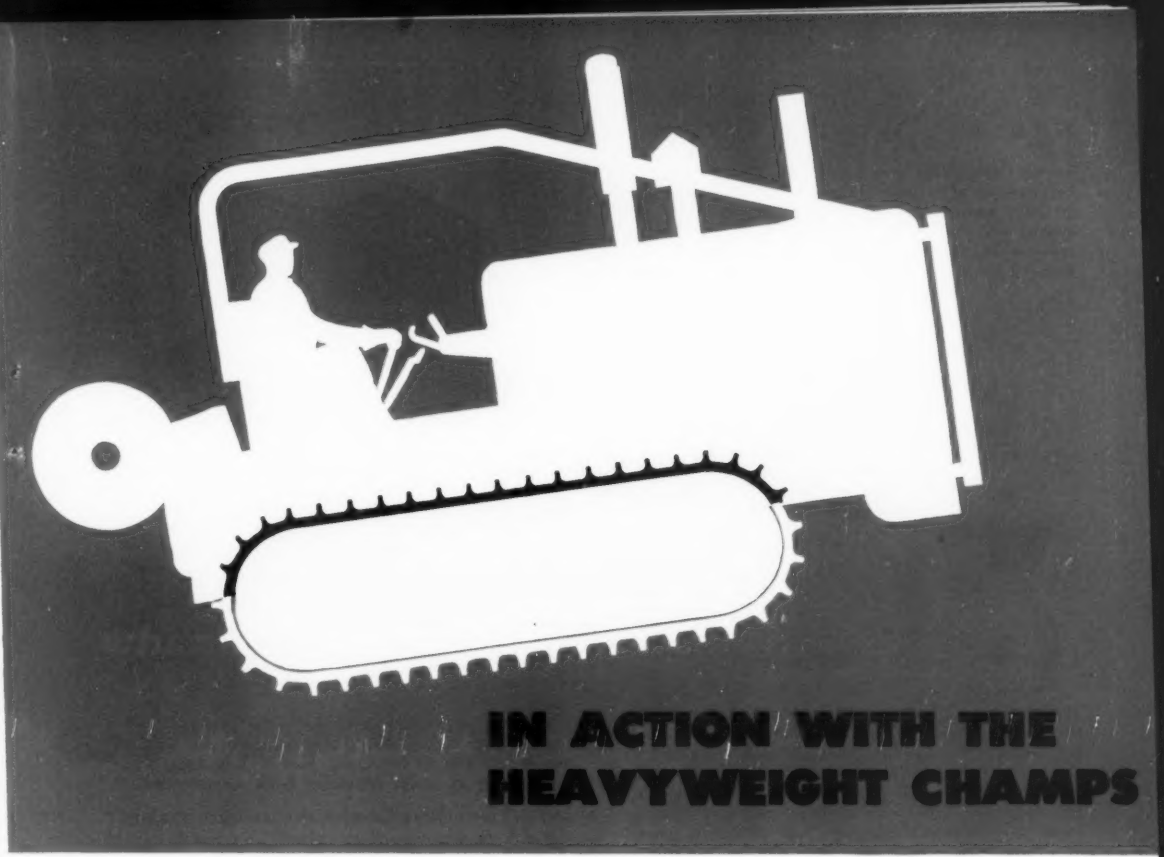


on the units are capacitor start, induction run in single phase models. Three phase models are also available. Units are supplied with $\frac{1}{4}$, $\frac{1}{3}$ and $\frac{1}{2}$ hp motors. They are resilient mounted and have automatic overload relays. Shafts of the pump and motor are connected through a reinforced flexible coupling. The motor-driven pump unit is supported soley by the motor base.

Metallic Rectifier

Kotron Div. of Standard Arcturus Corp., Newark, N. J.

This three phase bridge metallic rectifier delivers 10 to 50 times the direct current of conventional stack ratings, yet occupies considerably less space. The weight is less than one half that of competing rectifiers of the same



IN ACTION WITH THE HEAVYWEIGHT CHAMPS

To meet the needs of construction men and loggers, tractor manufacturers keep building bigger and bigger models. The largest tractors on the market today . . . giants that put plenty of wear and tear on brakes and clutches . . . use R M friction materials as original equipment.

That's another example of R M leadership in developing new friction materials to meet new industrial requirements. Through the years, R M has led not only in developing new sizes of friction materials (from the largest to the smallest available) . . . but also in new formulas (dry process, semi-metallic, and flexible pulp, to name a few) . . . and in new *installation methods* (bonding, for example).

Whatever your problem in brakes or clutches, call in your R M representative. He'll welcome the chance to help you. And he'll call, when needed, on the experience of four great plants, four research organizations, and four testing laboratories . . . assets that become yours when you deal with the world's largest producer of friction materials.

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION **620 Fisher Bldg., Detroit 2, Mich.**

445 Lake Shore Drive, Chicago 11, Ill. 4651 Pacific Blvd., Los Angeles 11, Calif.

1071 Union Commerce Bldg., Cleveland 14, Ohio

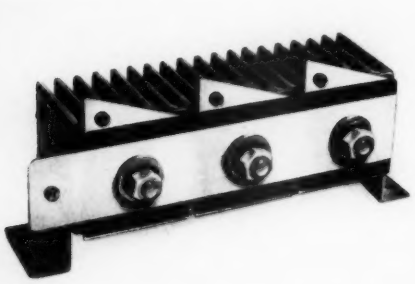
Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C.

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

RM

FIRST IN FRICTION

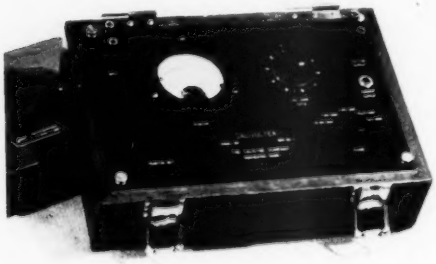
current rating. This device, called the Powerector, stands overloads up to 50 times normal. Actual ratings are up to 10 times normal output in still air, and up to 20 times normal with fan or water cooling. It is available in a-c rms blocking voltages up to 40 volts per cell. The maximum efficiency is obtained at the maximum temperature.



Laboratory Source of Potential

The Calidyne Co., 751 Main St., Winchester, Mass.

This unit is a laboratory standard source of potential for use in calibration of amplifiers, indicating and recording systems, transformers gains and meter sensitivities from d-c or 0 to 100,000 cps, when powered by a suitable battery or oscillator. It is particularly useful in calibrating equipment used in seismology, electro-encephalography and vibration measurement, as well as in general laboratory calibrations. It has low frequency characteristics and wide voltage range. Potential ranging from 1 micro volt to 1 volt are obtainable by direct reading from a continuously variable dial. Since output is obtained from a circuit whose impedance varies from 1 ohm to 100 ohms, the instrument is useful in calibrating circuits having a low input impedance. The high range of instrument may be increased conveniently by plugging

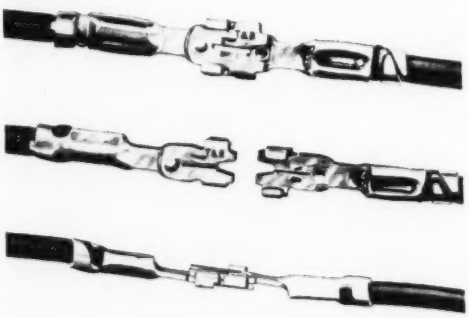


in standard resistors. The Calivolter, as it is called, is extremely useful also in measurement of voltage levels to a high degree of absolute accuracy by the substitution method, wherein an uncalibrated detector is used to measure both the unknown voltage and a known voltage from the Calivolter, which is adjusted to give the identical reading on the detector. It can be quickly and easily checked against certified standards.

Heavy-Duty Foot Switch

General Control Co., 1200 Soldiers Field Rd., Boston, Mass.

In this new foot switch a cast metal boot extending on both sides and over the top of the foot pedal affords protection against false operation by falling objects or unintentional operation. Contact elements are furnished in several styles: normally open, normally closed, or double-throw spring return; alternate contact operation, either single or double-throw; and two-stage double-pull, single-throw. Ratings are 10 amp at 125 v, a-c, and 20 amp at 125, 250, or 460 v, a-c. Base is 8 in. long, 5 in. high and 5¼ in. wide. Mounting holes are provided.

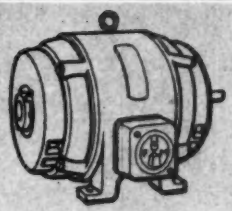


Electrical Connection

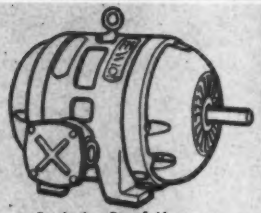
The Thomas & Betts Co., Inc., Elizabeth, N. J.

Called the Wristlock, this electrical connector is designed for use in installations where connecting or disconnecting may be expected. Especially adaptable for use with relays, signal or elevator equipment, and many types of fractional horsepower motors, it consists of two similar parts or halves which are simply meshed and locked securely together by hand. It is disconnected by merely pushing each half toward the other. The device will not let go in line of pull, and cannot swivel out of connection. It makes a positive electrical connection, features a brazed barrel giving extra strength, and also an insulation grip.

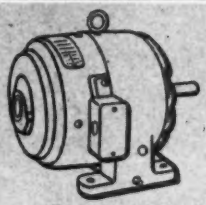
Vertical Motors



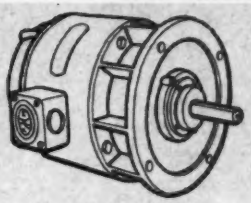
General-Purpose Ball-Bearing Motors



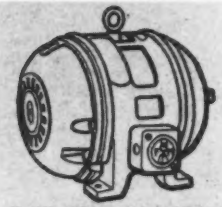
Explosion-Proof Motors



Motorgears

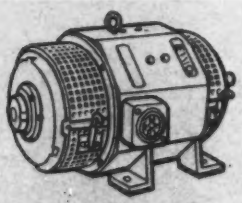


Flange-Mounted Motors



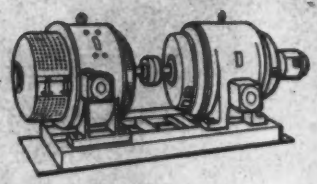
Totally Enclosed Fan Cooled

when it comes to Motors...



D.C. Motors

You stand to gain much in dealing with your Fairbanks-Morse Branch or Dealer as the single source for *all* your electric motor requirements. Not the least are the benefits of undivided responsibility, unprejudiced advice and application assistance. For your copy of the handy "Pocket Panorama" which illustrates the complete line . . . write Fairbanks, Morse & Co., Chicago 5, Illinois.

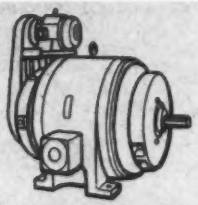


Motor Generator Sets

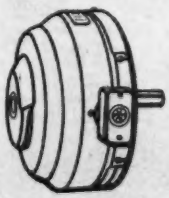
FAIRBANKS-MORSE

A name worth remembering

DIESEL LOCOMOTIVES • DIESEL ENGINES • PUMPS • SCALES • MOTORS • GENERATORS
STOKERS • RAILROAD MOTOR CARS and STANDPIPES • FARM EQUIPMENT • MAGNETOS

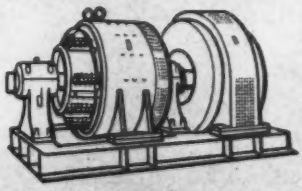


High-Speed A.C. Generators



Axial Air Gap Motors

Low-Speed A.C. Generators



Frequency Changer

Small Centrifugal Blower

Fairchild Camera and Instrument Corp, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.

Model 805J has a smooth, quiet operation because of a synchronous hysteresis motor, balanced fan and special vibration mounting. Designed for electronic tube cooling and small area ventilation, it can also be used in television cameras, instrument cabinets, and racks and panels. It is 4⅜ x 3 15/16 x 3 27/32 in. in dia., weighs 24 oz, and delivers air at 20 cfm. It operates on 115 v, 60-cycle a-c power with 0.150 amperes. Speed is 3,599 rpm; input, 15 watts; power factor, 85 percent; condenser, 0.50 mfd 300 v alternating current.

Locknut

Security Locknut Corp., 1815 N. Long Ave., Chicago 39, Ill.

Positive locking, exact nut adjustment, speed of application, and economy are the main features of this locknut. It can be applied in either direction, and stays exactly where it is put by wrenching, without requiring bolt tension. It consists of a standard steel nut, in sizes from ⅜ to 2½ in., both National Coarse and National Fine threads, combined with a slightly elliptical retainer ring. When applied, the bolt forces the heat-treated alloy steel ring into circular shape, causing a clamping action that does not loosen under severe vibration. The nut may be removed and re-applied over and over again without damaging either the nut or bolt.

Accelerometer

The Calidyne Co., 751 Main St., Winchester, Mass.

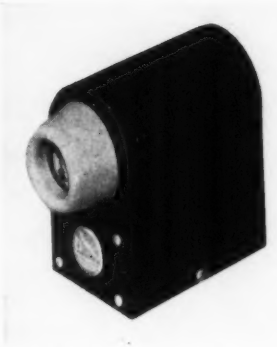
The model 18 accelerometer is a newly designed pickup allowing greater combinations of high frequency range and high output sensitivity in a direct current operated device. The natural frequencies available in the standard design range from 80 to 450 cps. Special pickups can be made with natural frequencies up to

1,700 cps. Standard units are capable of delivering a current of 200 microamperes into a load of 1,000 ohms or less at full range acceleration, and may be directly coupled to recording oscillograph elements. Pickups are damped, individually calibrated, and supplied with a 6 ft shielded pigtail. The pickup alone weighs 2 oz, or, with special designs, uncased, only 5 grams.

Photoelectric Control Unit

Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.

Type 23LF3 high speed, sensitive photoelectric control is to be used primarily for maintaining an accurate register of paper and cellophane which is being processed for bags and wrappers. It can also be used for various inspection applications, such as detecting the presence of seams and blemishes in the textile sheeting

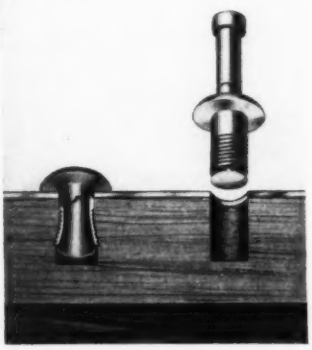


material, and inspection for proper labeling on bottles and packages. The control is supplied with type 42KK1 scanner, which consists of light source, phototube and amplifier tube in a single small housing. The unit uses long-life vacuum tubes throughout the amplifying system instead of the usual gas-filled thyratron-type tubes. The pertinent specifications are: supply—100-200 v or 220-240 v, 60 cycles; contact—single-pole, double-throw relay; contact rating—10 amps, 115 v, a-c, non-inductive, or 5 amps, 230 v, a-c, non-inductive; speed of response—impulse of less than 0.001 sec.; size of light spot—$\frac{1}{8}$ by $\frac{1}{64}$ in.; ambient temperature—32 to 100 F; and net weight—20 lbs, total.

Wood Rivets

Cherry Rivet Co., 231 Winston St., Los Angeles 13, Calif.

These rivets are well adapted to wood, metal to wood, and soft metal applications. When the insert (see illustration) is driven into the hollow rivet it expands the outside ser-



NEWEST LAB FURNACE!

HEAT-POWERED WITH NICHROME*V

Hevi Duty Electric Company has introduced a revolutionary new development in laboratory furnace equipment—for requirements such as drying of precipitates, ash determinations, fusions, ignitions, heat treating, enameling and ceramic firing, and general laboratory work.

Housed in a cylindrical shell, the furnace is mounted with practically line contact on a base containing instruments and controls—a type of construction that permits the base to remain at almost room temperature, with instruments and controls easily accessible at all times.

Operating temperatures from 900°F. to 1850°F. are obtainable—precisely controlled by means of a manually operated 36-step, tap-changing transformer.

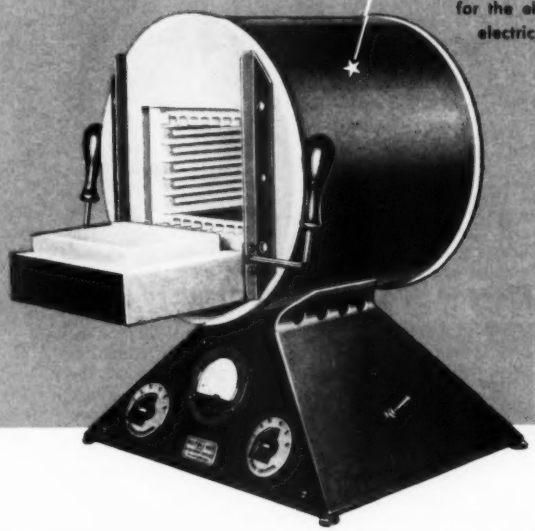
Outstanding characteristics of this new type furnace are rapid heating (about 85 minutes from cold to maximum temperature), and quick response to demand for temperature change.

To assure heating elements that will "stand the gaff" and give top-level performance under such punishing conditions, Hevi Duty Electric Company uses high heat- and corrosion-resistant Nichrome V. The absolute uniformity of this superior alloy assures even heat distribution; its retention of physical and electrical properties at high temperatures, enables critical adjustments to be made and maintained; its resistance to thermal shock assures long life, completely dependable and economical service.

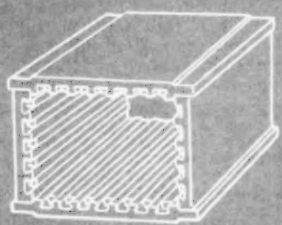
Whatever your electrical resistance problem, consult with us. In addition to world-famous Nichrome V and Nichrome, we make over 80 alloys for the electrical and electronic industries—the *most complete line* of electrical resistance alloys in the world.

New Model 651 Hevi Duty Muffle Furnace

Standard for use on 115 v. or 230 v., 50 to 60 cycles, A.C. Input: 1150 watts. Maximum operating temperature: 1850°F. 36-step control down to approximately 900°F. Heating elements: 22 gauge Nichrome V wire.



Heating units, top and bottom, are interchangeable; likewise, the two side units. All units are easily replaceable and reversible (permitting the coiled Nichrome V wire to be exposed or muffled).



NOTE: Nichrome V elements are also used in standard model, industrial Hevi Duty furnaces designed for operation up to 2000°F.

*Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle
Manufactured and sold in Canada by
The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

50TH YEAR
SPECIAL PURPOSE ALLOYS SINCE 1890
D/H
1899 - 1949

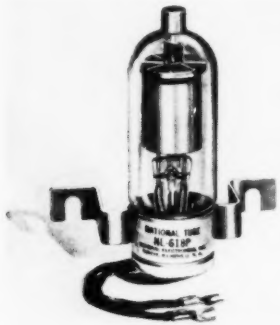
*T.M. Reg. U.S. Pat. Off.

rated sleeve to form a tight joint. Used with wood, the rivet carries a tensile load limited only by the strength of the wood. With metals, the rivet rails in tension without being pulled from the hole. Since tapping or the use of special inserts is not required, the rivet has many soft metal applications.

Industrial Rectifier Tube

National Electronics, Inc., Geneva, Ill.

Designated type NL-618P, this new xenon-filled rectifier tube has a 6.4 amp d-c output current rating. It utilizes a bracket type base for panel mounting without the use of a socket. Some of the specifications are: fila-

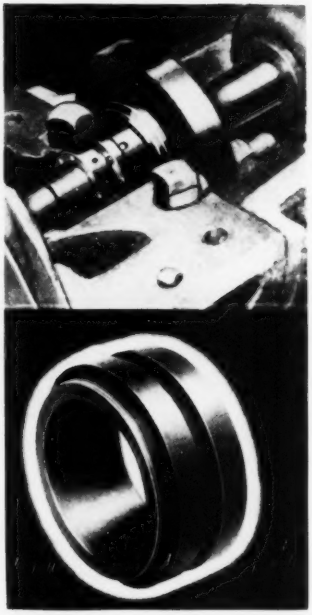


ment voltage, 2.5 v, filament current, 17 amps, peak inverse voltage, 750 v. It may be used at any ambient temperature between —55 and +70 C. Heavy leads and terminals carry the filament current and eliminate the problem of pin contact.

Self-Lubricating Carbon Steel

Morganite, Inc., 3302 18th Ave., Long Island City, N.Y.

Ability to withstand corrosive chemicals is an outstanding feature of this self-lubricating mechanical seal. It offers a perfect seal for highly volatile fluids under high presures and performs satisfactorily in continuous service at high shaft speed. The carbon seal is immune to most chemical attack and provides fool-proof sealing free from warping and gumming. No lubrication is required during the life of the seal. Hence, it is particularly adaptable for installation in inac-

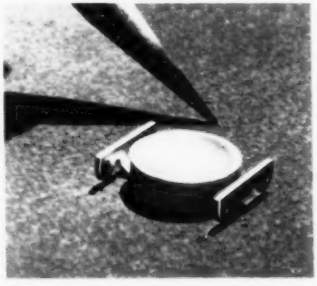


cessible locations where maintenance and servicing would be difficult. They are recommended for use in pumps, agitators, mixers, and similar installations. Pressure seal units of Morganite are available with self-adjusting and wear compensating features combined with self-lubricating properties.

Compact Thermostat

Stevens Mfg. Co., Inc., Mansfield, Ohio

Close temperature control of electronic devices is obtained with this compact, quick make and break thermostat. It uses a bi-metal thermal element of disk construction which allows the close control. The thermostat operates on a relatively small differential, with



a maximum operating temperature of 600 F. Temperatures as low as —60 C. do not impair normal operation. Two types are available—standard closure for normal operation and hermetically sealed for special operations. Both are pre-calibrated.

Oil-Filtering Material

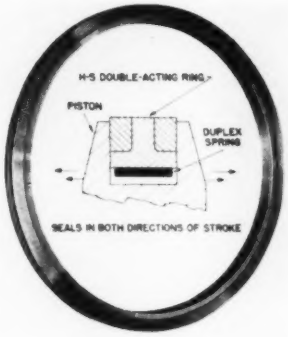
The Hilliard Corp., Elmira, N.Y.

Called Hiltex, this filtering material is made of combed, high-grade cotton combined with fine Sequoia bark fibers. Uniform density and light weight make it easy to handle and pack and gives the material a large dirt capacity. It is supplied in 2½ lb batts and is approved for the filtering of mineral, additive and detergent type oils. Samples are available.

Piston Ring

Hunt-Spiller Mfg. Corp., 383 Dorchester Ave., South Boston 27, Mass.

This new three-piece piston ring is for use with steam operated air pumps, steam and air cylinders of stationary air compresors, and in various other



pumps and air cylinders. The outstanding feature of this ring is the three-piece design which eliminates blow-by in both directions of the stroke, and thus acts as two rings. These rings are made in three pieces, a center section is T-shaped and two flat sections which fit into the relieved sections of the "T." Each of these pieces is cut into segments and the segments are dowelled in position so that the gaps between them cannot align. The number of segments depends upon the size of the ring. The installation of Hunt-Spiller Double

THE GOOD RIGHT HAND OF INDUSTRY

Worthington CN Centrifugal Pump—its short oversize shaft means better service, longer life.

It's Versatile . . .

takes whatever drive is

handiest

Meet the "any-drive" pump—the new Worthington CN many-purpose Centrifugal that can be driven by the most convenient means available.

It's another general utility pump like the famous Monobloc—but without the motor. The liquid end is mounted on a frame, from which the shaft extends to be coupled to a motor, fitted with V-belt sheave, or what have you. In an emergency, you can quickly shift to another type of drive.

It's *rugged*—designed for overhung pulley-drive—rigid shaft maintains perfect alignment of pump parts. It's *flexible*—use interchangeably either packed stuffing box or mechanical seal.

More Pumps "Across the Board"

Worthington makes all types, all sizes of standard pumps. When you reach the point of specifying a pump for your equipment, remember that no company offers more pumps—no company offers more value in pumps—than Worthington. Send coupon for free bulletin showing why, in pumps, *there's more worth in Worthington.*

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WORTHINGTON PUMP AND MACHINERY CORPORATION
PUMP AND COMPRESSOR MERCHANDISING DIVISION
HARRISON, NEW JERSEY

The Good Right Hand of Industry

POWER TRANSMISSION: sheaves, V-belts, variable speed drives
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Harrison, N. J.

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Company.....

Address.....

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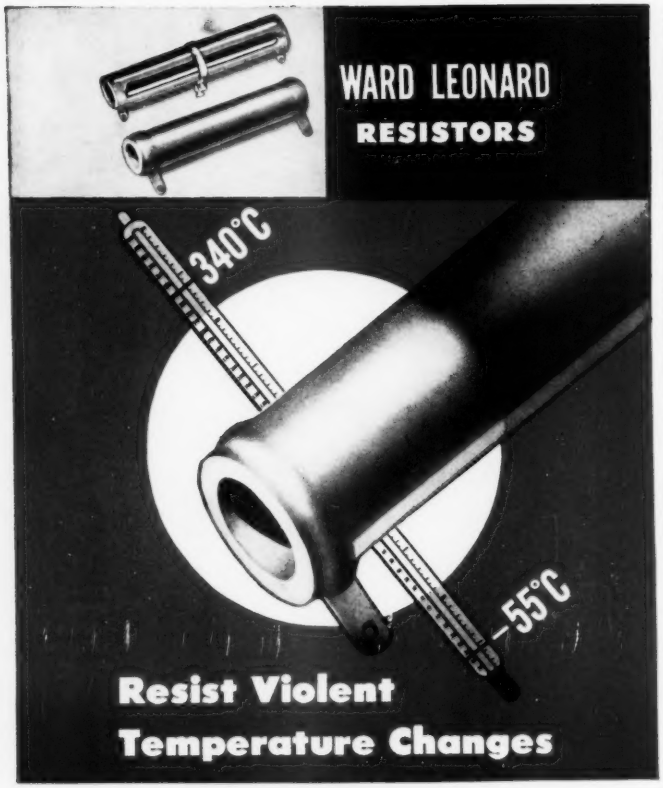


because all parts are

MATCHED

for thermal characteristics

Switch the temperature back and forth from 340 to —55°C, over and over, and still you won't affect the stability of Ward Leonard Vitrohm Resistors.

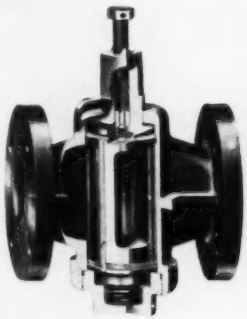
Reason is: Ward Leonard, making all components*, can control thermal characteristics so as to survive the greatest temperature variations.

Write for Vitrohm Resistor Catalog, Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

**Vitreous enamel coating and ceramic cores formulated and made by Ward Leonard . . . wire drawn to Ward Leonard's specifications.*

WARD LEONARD
ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Acting Rings on new equipment is simplified because only one groove has to be machined around the piston head. When being installed as replacement equipment, the material between the grooves for single rings is machined out and the proper Double Acting Ring and Duplex Spring inserted. Double Acting Rings are made in sizes and widths for all replacement installations.



Lubricated Plug Valve

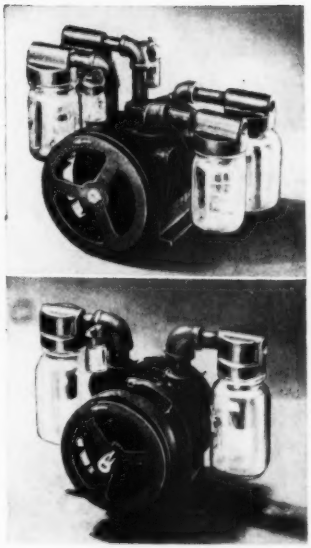
Homestead Valve Mfg. Co., Coraopolis, Pa.

Automatic compensation for wear in this new valve makes possible longer leakless service. The cylindrical plug of the valve has a wedge action which adjusts itself and keeps sealing surfaces of plug and body in constant contact. This wedge provides an extra tight seal against leakage, and gives lower lubricant losses. Line fluid pressure also helps promote the sealing effect. Port areas are equal to the area of standard pipe with a complete lubricant seal around them. Positive, visible stops limit operation to a quarter-turn. Valve is called Homestead-Reiser Self-Sealed Valve.

Air Pumps for Automatic Heating

Gast Mfg. Corp., Benton Harbor, Mich.

Specially engineered for automatic feeding operations, these three rotary-vane air pumps are available for original equipment applications. They meet requirements for feeding paper, cardboard, light metal or plastic materials on printing presses, folding and packaging machines, punch presses, etc. The rotary-vane design runs quietly and produces a pulseless air delivery. The dual chamber model delivers air pressure on one side and



vacuum on the other. All three models are equipped with ball bearings and V-belt pulley with integral fan for cooling and drive. The small dual pump, Model 10x1040, delivers 9 cfm from each chamber at 1,200 rpm. Either or both chambers produce vacuum to 20 in., or pressure to 20 psi. The large dual pump delivers 14 cfm from pressure chamber and 9 cfm from vacuum chamber. Up to 15 psi pressure and 15-in. vacuum is developed. The Model 3040 single chamber pump produces moderate pressure or vacuum with volume of 19 to 24 cfm, depending on the speed.

Hydraulic Packing Expander

HPL Mfg. Co., 2013 *E. 65th St., Cleveland* 13, *Ohio*

Called the U Expander, this new device comes in strip form, and can be cut off in the required length to fit any diameter of packing. The device is used to exert the proper mechanical

semi-knife-edge bearing reduces frictional wear

This is Ward Leonard's new Bulletin 110 Midget Relay for long, trouble-free service, particularly in equipments subject to vibration.

Exceptionally good vibration characteristics are due to proper proportioning of contact masses and springing combined with heavy pressures on both normally open and normally closed contacts.

Higher contact ratings than most midgets. Available up to 3-pole, double throw. Contact finger leads are insulated with the new, impregnated glass-fiber tubing.

Write for Bulletin 110. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Silicone News

DC SILICONES

NO OIL CHANGE FOR 5 YEARS!

Dow Corning 200 Silicone Fluid Adds Years Of Life To Oil Burner Fan Motors

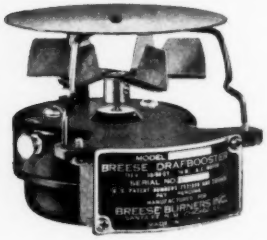


Photo courtesy Breese Burners, Inc.

Bearings of the BREESE DRAFBOOSTER oil furnace fan motor are lubricated with DC 200 Silicone Fluid to give years of satisfactory maintenance-free service.

Breese Burners, Inc., Santa Fe, New Mexico, manufactures the Drafbooster, one of the best fan motors available for oil-fired furnaces. Years of research and testing are incorporated into the design of this efficient unit and only high grade materials are used in its construction. Breese engineers learned, however, that in spite of well written instructions, few customers bothered to change oil each year. After two or three years' use, the oil was so badly oxidized and carbonized that the entire unit had to be replaced.

In 1944 Breese engineers obtained a sample of low viscosity DC 200 Silicone Fluid and subjected it to accelerated breakdown tests similar to those set up for testing the mineral oils Breese had been using.

M. D. Huston, Mgr. Sales Engineering for Breese, had this to say about the breakdown testing: "To our great surprise, the silicone fluid worked perfectly and showed no signs of oxidation or other deterioration. We immediately put Drafboosters containing DC 200 on lifetime field tests under the most severe operating conditions. A recent check of one unit which has been working since 1944 revealed the DC 200 Silicone Fluid is still just as good a lubricant as when it was put in. In August, 1948, we standardized on DC 200 Fluid for all our Drafboosters."

For more information about Dow Corning Silicones call our nearest branch office or write for booklet AC10.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Atlanta • Chicago • Cleveland • Dallas
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In Canada: Fiberglas Canada, Ltd., Toronto
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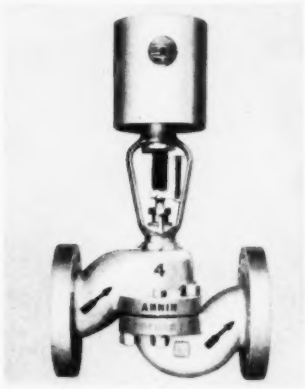
FIRST in Silicones
Dow Corning

strip material. It is impervious to maintain contact with the cylinder wall or plunger in cases where the pressure is either low or built-up. This strip is produced in several heights of a specially rolled brass strip material. It is impervious to corrosion from brine solution, gasoline, alcohol, and other such solutions.



Pneumatic Solenoid Valves

The Annin Co., 3254 Mines Ave., Los Angeles, Calif.

Fluid pressures up to 3,000 psi are controlled positively by this new valve. It is actuated by a secondary pressure source, such as air, gas or liquid at pressures from 50 to 300 pounds. This pressure is pushed through a three-way pilot solenoid to control valves in sizes $\frac{3}{4}$ through 8 inches. A bubble-tight shutoff is guaranteed through many thousands of operating cycles by the manufacturer. Valves are available in the following alloys: carbon steel, type 316, stainless, Durimet 20, Hastelloy "B"-"C"-"D," nickel and Monel. They can be used with fluids such as liquid oxygen, fuming nitric acid, sulphuric acid, and alcohol. Fluids carrying solids are also easily controlled by this valve.

Square Mesh Wire Cloth

Wickwire Brothers, Inc., Cortland, N. Y.

Transverse wires in this wire cloth are joined by electric welds at the crossing points. The welding eliminates crimping or interlocking of the cloth and gives it added strength. Wires used are heavily galvanized to prevent rust, wear or dirt accumulation. They are also available in a plain steel finish. Finer gage wires are used, and, since they are uniformly level, there are no uneven knuckles.

IRIDITE

gives galvanized parts

2-way

RUST PROTECTION

A clean, sanitary appearance and freedom from corrosion are "musts" inside this beverage cooler manufactured by The Vendo Company, Kansas City, Missouri. That's why Iridite was chosen to finish hardware parts and the galvanized vending basket. Iridite stops galvanic corrosion because it forms protective barrier between dissimilar metals. Iridite blocks corrosion from moisture because it seals the metal from contact with condensed moisture.

3 WAYS TO USE IRIDITE

Iridite offers you a complete line of finishes for any zinc or cadmium surface . . . plated, die cast or galvanized, and for any finishing problem . . . corrosion resistance, paint base or eye appeal.

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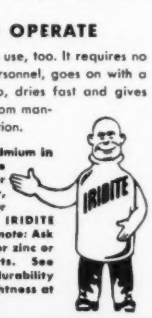
You'll find Iridite easy to use, too. It requires no special equipment or personnel, goes on with a short, non-electrolytic dip, dries fast and gives uniformly good results from manual or automatic application.



If you use zinc or cadmium in any form, you can use Iridite. Write today for data and samples, or, send specimens of your product for FREE IRIDITE PROCESSING. *Special note:* Ask about Iridite Bright for zinc or cadmium-plated parts. See how you can get durability and chrome-like brightness at amazing low cost.

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WHATEVER THE . . .
SIZE Precision Tubing is available in sizes which cover a range of 0.500 inches to 0.010 inches outside diameter, wall thicknesses down to 0.0015 inches. Through continuous hydrogen atmosphere annealing furnaces and tungsten carbide tooling, dimensions you specify within this range are held to extremely close tolerances.
SHAPE Precision Tubing can be drawn to almost any shape desired and is often preformed to facilitate secondary operations. Round, rectangular, oval, or square—any dimensions you specify within Precision's standard ranges are produced to meet the most exacting dimensional requirements.
ALLOY Precision's continuous endeavor to use only the best metal for any particular application has imbued it with a sound working knowledge of an almost limitless variety of non-ferrous alloys. Controlled production cycles make possible the correct temper, a clean smooth finish, and the precise uniformity so essential to long life.
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COUNT ON PRECISION
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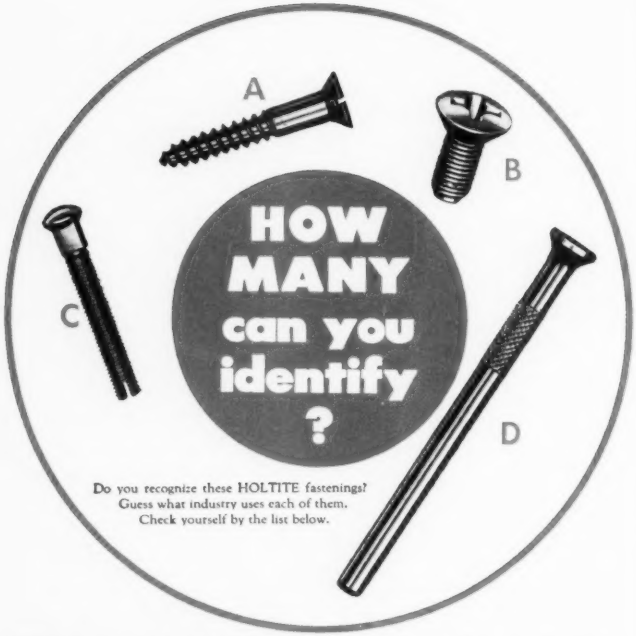
SPECIALISTS IN ACCURATELY DRAWN TUBING AND METAL SHIELDED WIRE
Factory: 3824-26-28 TERRACE STREET · PHILADELPHIA 28, PA.
BRANCHES IN ALL PRINCIPAL CITIES


A
B
C
D
HOW MANY can you identify ?
Do you recognize these HOLTITE fastenings? Guess what industry uses each of them. Check yourself by the list below.

CONTINENTAL makes them all and thousands more

Of all the 400,000 varieties of fastenings that literally hold our industries together, Continental makes a large proportion marketed under the famous HOLTITE trade name. Most of them are standard — screws, nuts, and bolts for every use in every industry. Others like the well-known HOLTITE-Sems and HOLTITE-Phillips screws are patented specialties and the famous HOLTITE-Thredlock, Locktite and Tap screws were first designed and produced by Continental. Sometimes a fastening engineered by HOLTITE for one industry finds an unexpected use in another. Often a HOLTITE-Engineered fastening will replace several parts that a manufacturer is using. Why not discuss your fastening requirements with a Continental Sales-Engineer. He will focus on your requirements all the broad industrial-fastening experience and ingenuity of Continental. Remember Continental is constantly improving HOLTITE products, lowering their cost and broadening service.

ENGINEERED FASTENINGS FOR PRODUCT ENGINEERS

A. A typical flat head HOLTITE steel woodscrew. Continental makes a complete range of sizes with either slotted or Phillips heads.

B. Special Phillips "HOLTITE-Thredlock" door hinge screw eliminates lock washers and other locking devices giving improved performance when subjected to vibration.

C. Dial adjusting screw specially designed for bathroom scales. Screw inserted in frame is swaged against square shoulder under head. Completed part engages scale leveling mechanism to allow screw driver adjustment.

D. Beater drive shaft for a home electric mixer. Continental engineered this unusual part and produced it economically by cold heading process. Head end is welded to the beater unit. Knurled section provides grip for motor chuck.

This Trademark HOLTITE T. M. REG. U. S. PAT. OFF. *means made by —*

CONTINENTAL SCREW COMPANY

1904 — 1949

NEW BEDFORD, MASS., U.S.A.

MEETINGS

October 5-8

SOCIETY OF AUTOMOTIVE ENGINEERS — Aeronautic and Aircraft Meetings and Engineering Display; Biltmore Hotel, Los Angeles, Calif.

October 10-14

AMERICAN SOCIETY FOR TESTING MATERIALS — West Coast Meeting; Fairmount Hotel, San Francisco, Calif.

October 11-14

AMERICAN STANDARDS ASSOCIATION—Thirty-first Annual Meeting; Waldorf Astoria Hotel, New York.

October 17-21

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Midwest General Meeting; Netherland Plaza Hotel, Cincinnati, Ohio.

October 17-21

AMERICAN SOCIETY FOR METALS—Thirty-first Annual Meeting and Exposition; Public Auditorium, Cleveland, Ohio.

October 24-26

AMERICAN GEAR MANUFACTURERS ASSOCIATION—Fall Meeting; Edgewater Beach Hotel, Chicago, Illinois.

October 26-27

FIFTH ANNUAL CONFERENCE ON INDUSTRIAL HYDRAULICS'—Sheraton Hotel, Chicago, Illinois.

October 27-29

OPTICAL SOCIETY OF AMERICA—Thirty-fourth Annual Meeting; Hotel Statler, Buffalo, New York.

October 31-November 2

PACKAGING MACHINERY MANUFACTURERS INSTITUTE — Seventeenth Annual Meeting; Edgewater Beach Hotel, Chicago, Illinois.

November 1-4

SOCIETY OF AUTOMOTIVE ENGINEERS—Diesel Engine, and Fuels and Lubricants Meetings; Chase Hotel, St. Louis, Missouri.

November 27-December 2

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting; Hotel Statler, New York City.

HOW WOULD YOU LIKE YOUR TUBING?

Rare... Medium... Well Done?

(Direct from the Welder) **(Partially Processed)** **(Fully Fabricated)**

The ELECTRUNITE menu is a varied one, including a wide selection of sizes, shapes, analyses, gages, physical properties and surface finishes. From it, you're sure to find the *one* tubing which best meets *all* of your application requirements.

DIRECT FROM THE WELDER TUBING . . . Produced to *your* requirements from either hot or cold rolled steel by Republic's improved electric resistance welding process. Delivered to you uniformly strong, clean and sound.

PARTIALLY PROCESSED TUBING . . . whether you require a special length, precision diameter or higher than standard physical properties . . . or a combination of these . . . ELECTRUNITE always comes to you as you like it.

FULLY FABRICATED TUBING . . . or, if your product requires a bent, swaged, flared, expanded or tapered part . . . or a completed assembly . . . Steel and Tubes' modern facilities and experienced personnel are prepared to handle the job for you.

See your nearest Steel and Tubes Representative or write *today* for more information.

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STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
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REPUBLIC STEEL
ELECTRUNITE TUBING

IF IT'S IRON OR STEEL

REMEMBER
to have it
HOT DIP GALVANIZED
(DIPPED IN MOLTEN ZINC)

"Hot-Dip" means actually dipping the steel in a tank of molten zinc. No other method of galvanizing will provide the fusion of metals and perfect seal necessary for effective rust prevention. You are assured a Hot-Dip Galvanizing job of the highest quality when you send your materials to a member of the American Hot Dip Galvanizers Association. For a list of members, write to the Association's headquarters in the First National Bank Bldg., Pittsburgh 22, Pa.

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STAINLESS STEEL FASTENERS

IMMEDIATE DELIVERY • ALL TYPES & SIZES

help make your products fully non-corrosive.....
For first-quality stainless fastenings see Allmetal first! All types and sizes of machine, set, self-tapping, wood screws, nuts, bolts, pins, washers, rivets, available for IMMEDIATE DELIVERY from America's most complete stock. Specials to order.

WRITE, ON YOUR LETTERHEAD, FOR CATALOG No. F49

STAINLESS STEEL FASTENERS

MANUFACTURERS SINCE 1929
ALLMETAL
Screw Products Co., Inc.
33 GREENE STREET, NEW YORK 13, N. Y.

OUR READERS SAY

Shall We Psi or Psig?

To the Editor:

I have noticed E. B. Bridgett's letter to the Editor in August, 1949, PRODUCT ENGINEERING requesting information as to where he can purchase a 6 in. solenoid gate or butterfly valve to operate from 440 v current. If compressed air at over 25 psig is available in Mr. Bridgett's plant, I believe there is a relatively simple solution to his problem.

I suggest that he purchase a 6 in. pneumatically operated diaphragm motor butterfly valve from the Mason Neilan Regulator Co., 1190 Adams St., Boston 24, Mass., or the Belfield Valve Division of Minneapolis Honeywell Regulator Co., Philadelphia, Pa. and a ¼ in., 3 way, 440 v solenoid valve for air service from 0 to 15 psig from the Minneapolis Honeywell Regulator Co.

As well as this equipment he will need an air pressure reducing valve to reduce the compressed air pressure down to 15 psig. The 15 psig air supply is connected to the solenoid valve and a connection made from the solenoid valve to the diaphragm motor of the butterfly valve. The butterfly valve is normally open with zero air pressure and closed tight with 15 psig pressure. The 3 way solenoid valve is connected in the air supply line in such a way that the air supply will normally be closed off leaving the butterfly valve open. When the solenoid valve is actuated by the 440 v source the 15 psig pressure is applied and causes the diaphragm motor to close the butterfly valve.

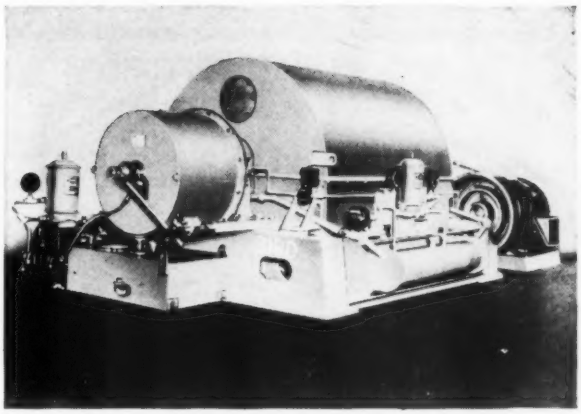
If all connections are kept tight, the system will be as reliable as the compressed air source. Very little compressed air will be used, probably much less than 1 cfm of free air.

—A. E. CHARD
Powell River, B. C.

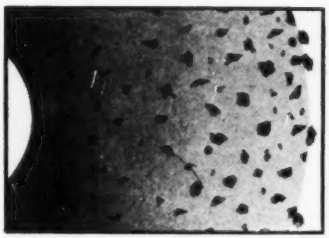
Ed.—Thanks for your interesting solution to Mr. Bridgett's problem. Outside of your helpful information, one of the interesting things about the letter is your use of the abbreviation psig.

We have been wanting to call attention to this common usage for some time, and are going to use your letter

Bird Machine Co., South Walpole, Mass. planned on providing the Bird Continuous Centrifugal Filter with one pint of extra heavy oil a minute to each main bearing and five gallons a minute of a pressure lubricant to the gear drive. And to make sure of *always-clean* oil, they specified Cuno MICRO-KLEAN Filters—guaranteed not to pass any solids larger than specified, exclusively constructed for double dirt capacity and minimum pressure drop. (Primary filtering is done by Cuno AUTO-KLEAN Filters—all-metal disc-type).

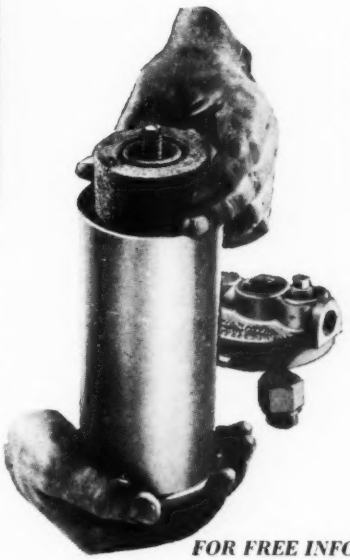


You're "Lube-Sure" with this Double-life Protection



Guaranteed Fluid Conditioning
... Double Cartridge Life

Cuno is the only manufacturer of replaceable-cartridge filters *guaranteeing* to remove all solids larger than specified, plus a large proportion down to 1 micron. MICRO-KLEAN's exclusive "graded-density-in-depth" permits smaller particles to penetrate to varying depths, eliminates surface loading, *doubles dirt holding capacity*. Resinous impregnation and polymerization prevents channeling, rupturing, shrinking and distortion.



Wide Range of Applications

Cuno MICRO-KLEAN filters come in varying densities . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

● Your nearby Cuno engineering representative, handling the broadest line of fluid filters, is your best source of unbiased recommendations on fluid filtration . . . he offers you, before and *after* installation, service based on years of experience with engineering filtration systems.

CUNO

Fluid Conditioning

Removes More Sizes of Solids from More Types of Fluids

MICRONIC • DISC-TYPE • WIRE-WOUND

Send Coupon
FOR FREE INFORMATION ON CUNO CLEANING

Cuno Engineering Corporation
302 S. Vine St., Meriden, Conn.

Please send information on Cuno Filter.

Name.....

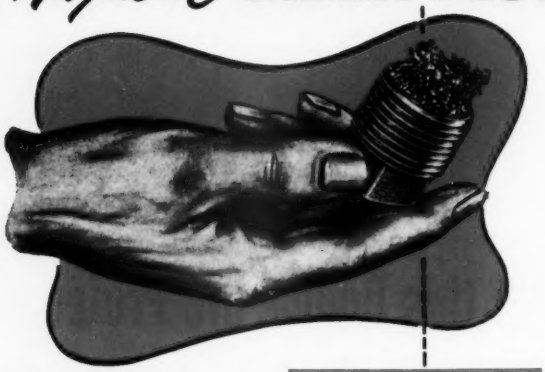
Position.....

Business Address.....

PLEASE ATTACH COUPON TO YOUR BUSINESS LETTERHEAD

LISLE

Magnetic DRAIN PLUGS

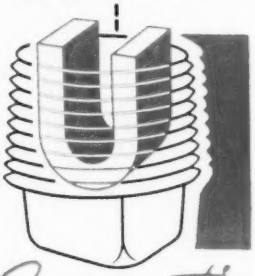


MAKE A FEATURE OUT OF A FUNCTION

● Specify Lisle Magnetic Plugs instead of ordinary drain plugs and get a low-cost feature that gives your product longer life . . . an added sales feature. The powerful magnet built into a Lisle Plug attracts and holds abrasive particles that flake off moving parts. Lisle plugs trap this "wild metal" *before* it can circulate in the lubricant. Prevents damage to gears or bearings. No change in design is necessary. Use inexpensive Lisle Magnetic Plugs instead of ordinary drain plugs and insure longer life . . . put another selling feature in the product you make.

WRITE

● **WRITE** for complete literature and sample Magnetic Plugs for testing. Mailed at once without obligation.



LISLE *Corporation*

811 EAST MAIN STREET, CLARINDA, IOWA

Makers of Lisle Ridge Reamers and Other Famous Automotive Tools

as an example. Now we think the "g" is superfluous in a case like this. Why not use psi unless you are dealing with absolute pressure? What about it readers, shall we use psi or psig?

Help For Inventors

To the Editor:

Your article in the July issue, page 154, about the National Society of Inventors was extremely interesting. I'm sure that many inventors and would-be inventors will find such a society a great help.

I wonder if this society intends to help people who have no patent, but have an economically sound idea that they don't quite know what to do with? I am thinking specifically of myself (as we usually do), and an idea I have for raising sunken ships easily, quickly, and cheaply.

I would appreciate any information you can give me about this society, including the address of the Washington Chapter, which you state is the only chapter yet formed:

—MILLARD W. WAGNON
New York City

Ed.—Here is the address you wanted, and we wish you luck in raising those ships:

THE NATIONAL SOCIETY OF INVENTORS, INC.
Benjamin Franklin Station
Box 7410
Washington 4, *D. C.*

More On Intermittent Motion Mechanisms

To the Editor:

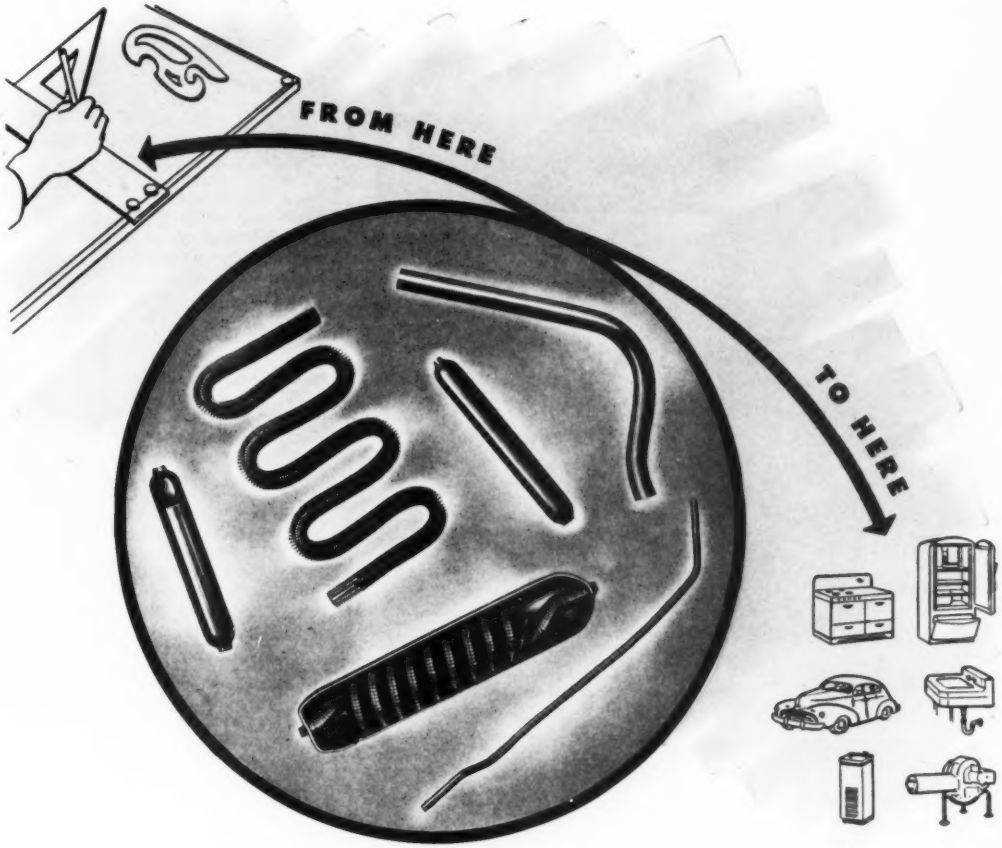
It may be of interest that the intermittent motion mechanism illustrated on page 117 of the August issue of PRODUCT ENGINEERING is of my invention, being described in U. S. Patent No. 2,237,108.

While it is realized that the purpose of your showing was merely to illustrate the principle of the mechanism, it has some features which may be of interest. One of these is that acceleration during the feeding stroke can be controlled by properly shaping the drop surface of the cam. This is important in high speed applications.

Another is the timing feature, since by rotating the cam, the point in the rotation of the driver at which the feed occurs can be adjusted at will, even when the mechanism is running.

A third is that quite a considerable torque can be transmitted, whereas the device shown in Fig. 9, for example, will wear very rapidly if loaded.

Finally, the arc of rotation in which



TUBING IS IMPORTANT

to all of you who buy or specify tubing

BECAUSE it means so much to

—the life of your product
—your company's reputation
—your customers' satisfaction

That is why Wolverine seamless, non-ferrous tube is preferred in the fabrication of tubular parts that serve as components of completed functional units. It is the tube that is quality-controlled from ore to finished product—every inch of the way.

Let **WOLVERINE** *fabricate tubular parts to your specifications*

WOLVERINE TUBE DIVISION
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED

MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING

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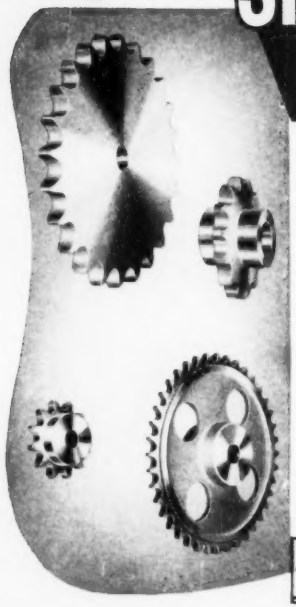

SEND FOR THE SEWALL CATALOG listing all types of stock sprockets. Sewall roller chain sprockets are available for conveying and power transmission uses. We cut sprockets to order for any type of roller or silent chain. Large and small sizes . . . any material or quantity.

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the feed occurs can be made quite small, both for the driver and driven elements. This is not possible with Geneva movements.

This intermittent motion device was aplied very successfully in the high-speed tape reader described in U. S. Patent No. 2,464,601, a copy of which is enclosed. This reader "read" small holes (0.05" dia on 0.10" centers) in paper tape at the rate of 20 readings per second. You will no doubt appreciate that when a complex cycle is executed in 1/20 of a second, close timing of the tape feed is essential. The tape was advanced in about 0.002 sec and the tape could be run over 1,000 times without breaking out the 1/3" dia feed holes. This reader was virtually noiseless, and ran continuously for over 6 months on life test.

As you know, new mechanisms and mechanical movements are rare, and in many years in developing special mechanisms, I devised perhaps five novel mechanical movements. The mechanism shown in your article has been published several times, but I have never received credit for it. Do you not agree that individuals should be credited with their inventions?

—H. J. NICHOLS
Point Pleasant, N. J.

Ed.—We certainly do agree that individuals should be credited with their inventions. The trouble is that it is physically impossible for us to trace the genealogy of every mechanism we print. A full time patent attorney would have to be added to our staff to do the job. It is unfortunate that this condition exists—but there you have it.

Thanks for pointing out some of the interesting design features of the mechanism. This information is a useful supplement to our short presentation.

A Reader Calls Us Down

To the Editor:

Kindly refer to the article Kinematics of Intermittent Mechanisms—the External Geneva Wheel, on page 110 of your July 1949 issue.

I believe that accuracy is a necessary virtue in any kinematic analysis, and an engineer who undertakes to author such an article accepts the responsibility of correctly stating facts. I am sure you will agree that most design engineers accept published data at their face value, oftentimes without checking the many steps in the derivation that have been omitted from the article itself.

Mr. Rappaport has labelled his abscissa of Fig. 6 as the angular accel-

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ORIGINALLY this combination gear and ratchet was machined separately and then assembled.

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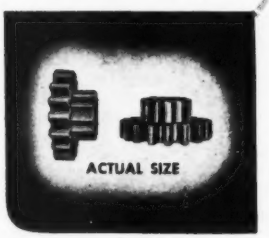

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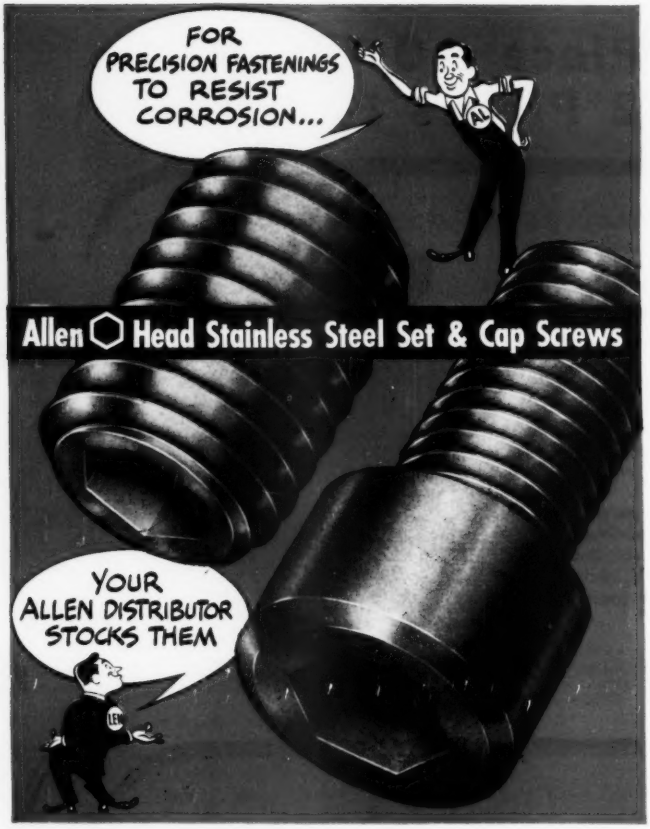
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Set Screws in popular sizes from No. 6, 3/16" length to 1/2" x 3/4". Cup points.

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eration of the driving crank, when actually he started his analysis by assuming that the driving crank has constant velocity and hence zero acceleration. I know that you and he can claim this to be a typographical error and that the correct title of the abscissa should read angular displacement instead of angular acceleration.

But how about the information contained in the curves of Fig. 6? Mr. Rappaport has already shown the velocity of the driven member to be a maximum at the point where the crank roller crosses the zero line, and that the velocity decreases to zero at the end of the drive period. His curves in Fig. 6 are then actually deceleration curves for the part of the cycle he is discussing.

How much better it would have been to have shown the full curves for the complete driving cycle. This can be done by rotating his set of curves first about the ordinate as though you picked the graph bodily out of the paper and tipped it over 180 deg. to the left. Then do the same thing about the abscissa by tipping the graph towards you about the bottom line until it is again in the plane of the paper. You will then have a true picture of the Geneva, showing acceleration to the midpoint and deceleration to the end of the motion.

I would appreciate your passing this on to Mr. Rappaport, for I am sure that few readers will be able to get a clear picture of the beautiful kinematics involved from his presentation.

—JOHN W. MAY
Stanford, Conn.

Ed.—That was no typographical error, Mr. May. That was a plain, old fashioned mistake. Since the displacement was measured in degrees, we hope that many readers realized our mistake and recognized angular displacement in spite of our mis-labeling.

The term "deceleration" is probably more graphic in this case than acceleration, but is no more correct. Acceleration is defined as the rate of change of velocity with respect to time, and may be either uniform or varying, positive or negative.

Now What Can You Do With a Shape?

To the Editor:

We have a rubber shape and we don't have any good ideas for using it. The rubber shape is an extrusion with a cross section in the form of a U. The U is flat across the bottom, and the legs have a bow so that the legs deflect outward with application of a load. The U shape is about

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for templates, cutting tools, gages, test tools, machine parts and many other items . . .

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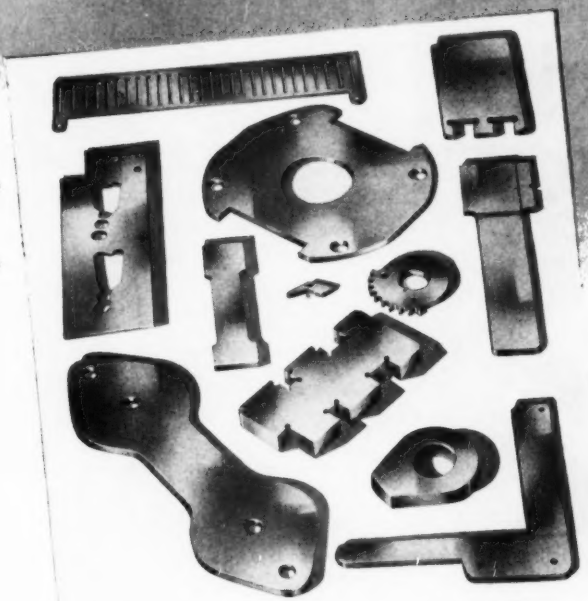

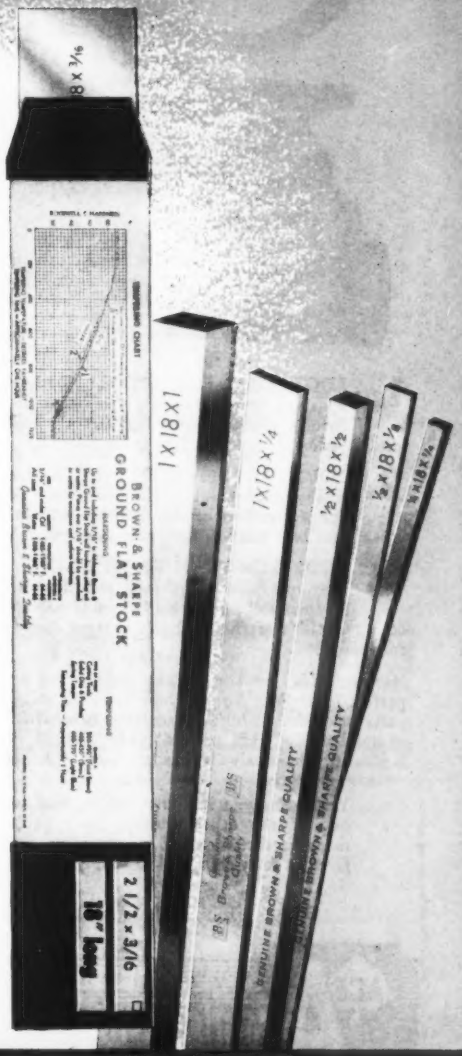

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Brown & Sharpe Ground Flat Stock is accurate to within .001" in thickness. It is selected first-quality tool steel, annealed uniformly by a special process to make machining easy. Up to and including 3/16" in thickness, hardens in either oil or water to 64-66 Rockwell C. Pieces over 3/16" should be quenched in water for full hardness.

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Regular stock sizes include 13 different thicknesses from 1/64" to 1/2" . . . widths up to 6" . . . also square sizes. Individually packaged in clean, protective envelopes marked with size and heat treating instructions. Easy to store. Easy to handle.

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Answers: No. 1—Ace red hard rubber was molded over steel core to give perfect foot ring. An idea here for you? No. 2—This is one of many pen parts machined at high speed from Ace hard rubber rods and tubes. Sizes as small as 1/16" O.D. up to 6" O.D. Samples on request. No. 3—Ace Saran is ideal for these valve bodies, products of Ace injection molding equipment.

Yes, sometimes it's hard rubber, and sometimes it's one of the other plastics that's best. Ace, with many hard rubber and plastics compounds to choose from, is fully equipped to supply whatever you need.

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1 in. wide and about 1 in. high. The load-deflection curve for a three inch length of the U is as follows: 1 lb equals 1/32 in. deflection; 5 lb equals 5/32 in.; 10 lb equals 5/16 in.; 25 lb equals 5/8 in.; 60 lb equals 15/16 in.

We will appreciate any suggestions offered.

M. L. EDWARDS
St. Louis, Mo.

Ed—We will gladly forward any suggestions from our readers to Mr. Edwards.

Where is Aluminum?

To the Editor:

I was shocked to see no mention of aluminum in the "Corrosion Guide for Fasteners" printed on page 161 of PRODUCT ENGINEERING's July, 1949 issue. On second glance, I note that it has evidently been reprinted from H. M. Harper Company's catalog, but I'm nonetheless surprised that aluminum fasteners haven't been included. Have you got the answer?

WILLIAM L. MCCAGUE
Aluminum Co. of America

Ed.—you are rightly shocked, Mr. McCague. It was a slip-up on our part to neglect aluminum in our listing of important metals used for fasteners. Of course aluminum resists corrosion in a majority of the corrosive media we listed.

Where Can I Get It?

Patent Rights

To the Editor:

I wish to obtain your advice with regards to the possible obtaining of Patent rights.

As acting manager for a firm engaged in the production of cream separator and woodworking machinery, we have worked on the plans and construction of a small type of molder, and we have made several attempts to improve and change different parts, before we decide to offer such machines on the market.

To my knowledge there is nothing on the machine to qualify it for patent rights. A few officers of our company have manifested the desire to seek patent rights and it is my intention to inform them why they are wrong if they are wrong.

The discussion is on the incorporation of the structure of the top and bottom cutting knives. Should your machine be large or small or different

REDESIGN TRIMS LENGTH 5¼ INCHES, CUTS UNIT COST $5.70

Series D Wayne water pump uses machined shoulders to position bearings on shaft. 2 Tr arc rings hold bearings in housing. Locknut holds screw-type stuffing box that requires periodic tightening.

New design uses 4 Truarc Inverted rings (2 external, 2 internal) to position shaft, retain bearings. Inverted rings provide shoulders of uniform section height. 1 Standard ring secures maintenance-free mechanical seal.

Redesign with Truarc Rings helps save $5.70 per unit for Wayne Home Equipment Company, Inc., Fort Wayne, Ind. It gives them a more compact product, eliminates a separate bearing pedestal and a skilled-labor grinding operation. It facilitates use of maintenance-free mechanical seal instead of old type stuffing box.

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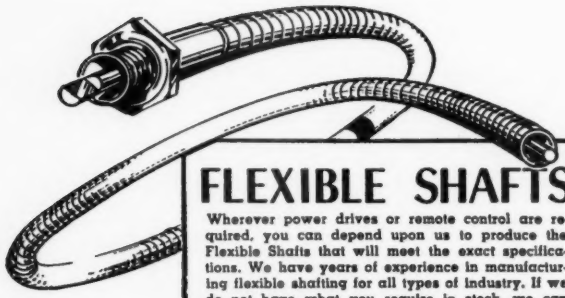

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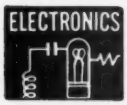
Wherever power drives or remote control are required, you can depend upon us to produce the Flexible Shafts that will meet the exact specifications. We have years of experience in manufacturing flexible shafting for all types of industry. If we do not have what you require in stock, we can make shafts to your specifications. Our engineers will be glad to work out your problems without obligation.



Many new uses for flexible shafts that carry power around any corner have been developed by our engineers . . . in machine shops, electronic, automotive, aircraft, in all industries where power drives or remote control are required. *Write for Manual P. E.*

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Standard or Special, ELECTRIC Spoke-type or Disc Wheels are built for most types of portable equipment.

Send us your specifications and we will submit our recommendations.

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in style, the top, bottom or side cutting knives will still remain on the same principle, and I don't believe them to be subject to patent rights.

EMILE ST. PIERRE
Verdun, Que.

Ed.—Rather than get embroiled in the maze of law—and especially patent law—we can only refer Mr. St. Pierre to a patent lawyer. A re-reading of the two articles (June and July, 1948, PRODUCT ENGINEERING) by Mr. Toulmin might help.

Porcelain Enameled Bearings

To the Editor:

We noticed with interest a letter to you from "D.D.B." on page 198 of the March, 1949, issue of PRODUCT ENGINEERING.

Would it be possible for you to forward us some information on name of a company from which we might obtain such information?

—J. W. BROWN
E. I. du Pont de Nemours & Co.

Ed.—We carried a short, news-type article on porcelain enameled bearings in our April, 1949, issue, page 152. For further information write Caldwell Glass Bearings, Inc., 3920 Kellog Ave., Cincinnati 26, Ohio.

Lead Screws

To the Editor:

Please send me any information you have on manufacturers or distributors of lead screws. I am interested in lead screws of high precision of the type used in comparators and other scientific instruments. I would greatly appreciate an early reply.

—JOHN D. ISAACS
La Jolla, Calif.

Ed.—Try the Pratt and Whitney Division of the Niles-Bement-Pond Co., 117 Liberty St., New York 6, N. Y.

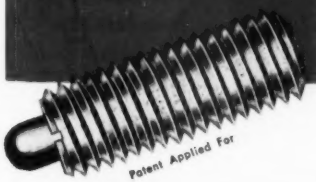
Lead Coating For Steel

To the Editor:

We wish to coat some pieces of steel with a layer of lead or babbit, $\frac{1}{4}$ to $\frac{1}{2}$ in. thick, and we are wondering if in your publication, at any time, there was any mention made of just how this should be done. If so, what would the price be for copies of the articles? W. WALLACE MCKAIG
Cumberland Steel Co.

Ed.—We haven't published articles on this subject, but it happens that the National Lead Co., 111 Broadway, New York 6, N. Y., had such a process. We suggest that interested parties contact them.

The USE of the VLIER UNITS as an important part of your end products is limited only



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Any product in which the steady, accurate tension of reliable spring plunger action is required, the use of VLIER ready-made, trouble-free Spring Plungers with pre-set end pressures is the answer. Offered in stock sizes, from #8-32 providing 5 lbs. end pressure up to ½"—13 with 12 lbs. end pressure to meet your every requirement.

The operation of the VLIER Spring Plunger is shown at left. The hardened, rounded plunger end telescopes within threaded body deriving its tension by action of accurately tested spring. Adjustment may be made from both ends. "DuLited" against rust.

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As knurled knob of VLIER Torque Thumb Screw is turned, torque is applied which is transmitted to screw, until prescribed resistance is developed. At this point ball, in head construction as shown at right, is depressed into cavity and the applied torque to screw ceases and no further pressure can be applied.

"TIGHT IS TIGHT ENOUGH"

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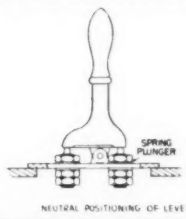
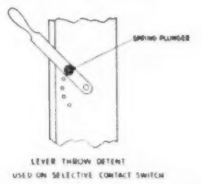
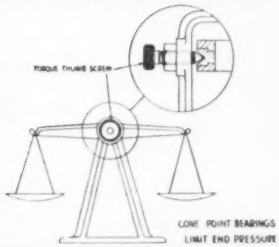
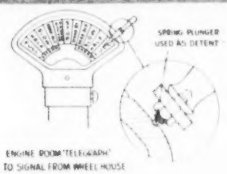
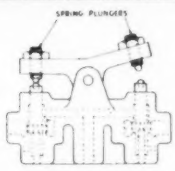
A few suggestions for application of VLIER UNITS in Products.

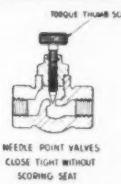












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Assure Longer Lasting Assemblies

The life of the assembly is usually determined by the length of the Power Zone of the fastening device. Diamond G Spring Lock Washers have been designed, developed and torture-tested to provide the maximum Constant Power Zone . . . longer positive holding power.

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NEW BOOKS

Properties of Metals In Materials Engineering

Symposium by eight authors under the auspices of the American Society for Metals. 177 *pages,* 6 x 9 *in. Published by the American Society for Metals, Cleveland, Ohio.* $5.00.

This book discusses experimental stress analysis techniques and their relationship to materials testing. The need for better understanding between the designer and the metallurgist is brought out in the introduction by R. L. Templin, Assistant Director of Research and Chief Engineer of Tests, Aluminum Company of America. He expresses the opinion that focusing interest on tests of actual structures may expedite the designer's understanding of the behavior of materials in structures under service loads.

N. Gensaner, Assistant to Director of Research, Carnegie-Illinois Steel Corp., points out that solid state physicists and designers differ in their interpretation of the phrase, "fundamental concepts." Because of this difference in point of view, it is important in physical testing to consider whether the test is performed to control the uniformity of a product, to collect design data, or to find ways of improving materials. Various methods of testing materials are discussed.

John R. Low, Jr., General Electric Co., Schenectady, discusses the behavior of metals under non-reversed loading. The stress-strain curves, including true strain curves, are given for tension, compression, and combined stress. A discussion of impact testing is included.

R. E. Peterson, Manager, Mechanics Department, Westinghouse Electric Corp., discusses stress concentration, notch sensitivity, and size effect. The relationship of these topics to the laws of probability is brought out in detail.

W. M. Murray, Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, discusses the determination of the state of stress. A brief general discussion of experimental stress analysis methods is given. In addition, a more detailed discussion of wire strain gages is included in this chapter.

William T. Bean Jr., discusses the stress analysis of aircraft engines. He shows how experimental stress analysis techniques can be applied practi-

HOT STUFF

—BUT dainty hands no longer have to be dunked in hot soapy water. Now, with this new die cast aluminum Park-Aid-Clothes Lifter, Mrs. America can more than ever maintain her daintiness on washdays. This newest application of modern die casting techniques permits her to lift clothing out of washing machines, boilers or tubs, surely and easily. Her hands need never touch hot water when removing the family wash. Die casting in either aluminum or magnesium offers many new roads for the low cost production of lightweight and durable products for manufacturers who plan ahead.

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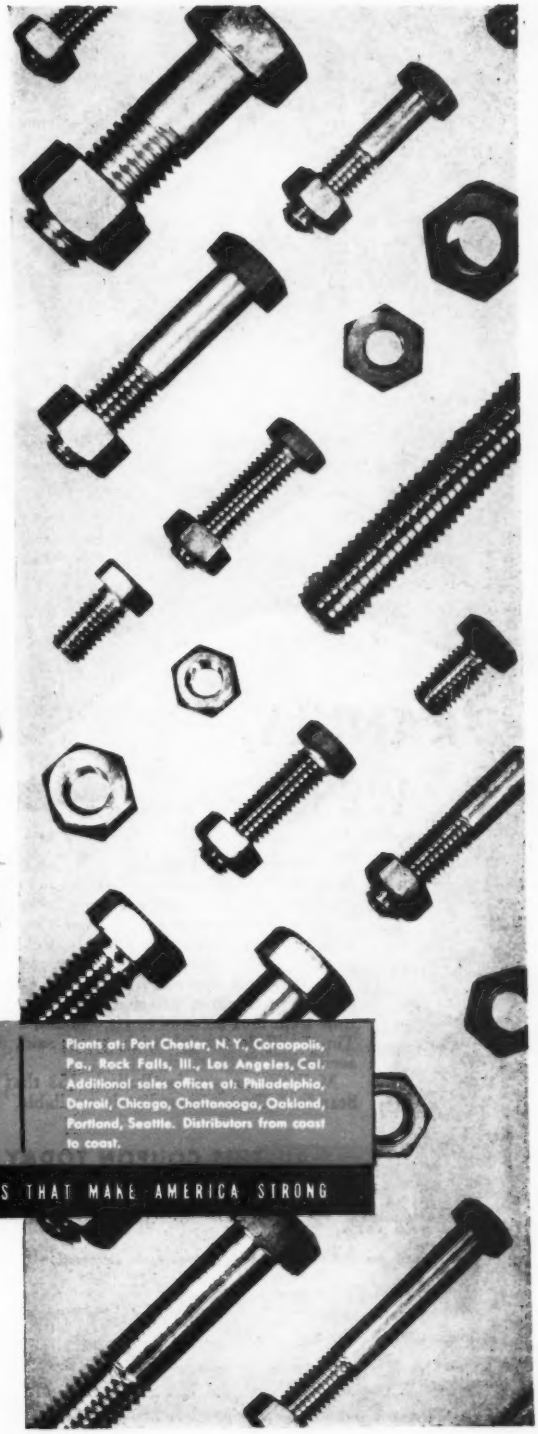

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cally to the design of aircraft engines.

E. C. Hartman, Chief, Engineering Design Division, Aluminum Research Laboratories, discusses testing to specific deflections (buckling). This is a general discussion of testing of assemblies with particular emphasis on buckling.

Wendell P. Roop, Research Consultant, Structural Research Laboratory, Swathmore College, discusses design for energy absorption. He treats the effects of impact and explains that they can be reduced by the proper selection of materials and by the proper design of the geometeric configuration of the structure.

Practical Television Servicing

J. R. JOHNSON and J. H. NEWITT, *334 pages, 6 x 9 in. Published by Murray Hill Books, Inc., 232 Madison Ave., New York 16, N. Y.* $4.00.

Starting with a clear explanation of the television process and receiver fundamentals, this book atempts to give the reader a full understanding of the whole receiver. The r-f amplifier stage, the mixer, i-f sections, detectors, video amplifiers, cathode ray tubes and synchronizing units are all described in detail. Particular attention is paid to the important servicing problems involved.

Theory, mathematics and general discussions are avoided. The practical side of television is stressed. The book provides an excellent source of information for the non-electronic engineer who wishes to have some understanding of the new field.

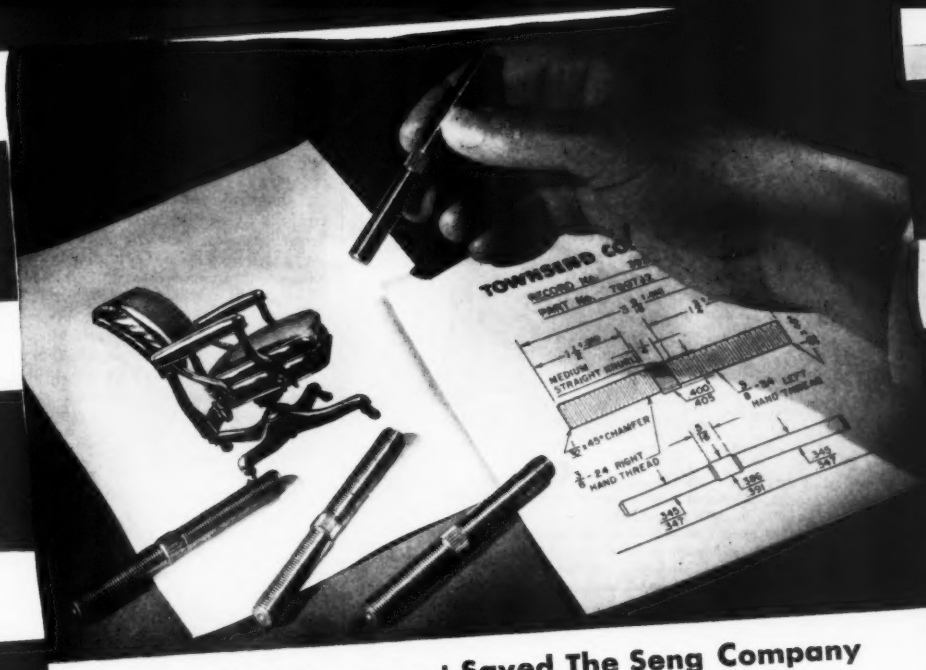
Some typical chapters are devoted to Synchronizing and Sweep Circuits; Antennae and Wave Propagation; Test Equipment and Alignment; Cathode-Ray Tubes; Common Troubles in Television Receivers and Color Television.

Patent Applied For

FRED COPPERSMITH and J. J. LYNX. *100 pages, 7½ x 10 in. Published by Co-Ordination Press and Publicity, Ltd., distributed by Technicosmos Co., 124 W. 80th St., New York 24, N. Y.* $3.00.

As its sub-title, "A Century of Fantastic Inventions," implies, this book deals entirely with the impractical.

In the 19th Century man was fast becoming aware of the glories of science. Technology was supposed to bring us peace, happiness, and prosperity in ever increasing amounts. The inventor was king and no invention lacked an interested (and



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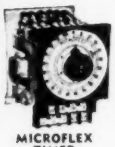

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sometimes wealthy) audience.

Most of the fantastic inventions shown in this book were used at least for a short time. Nearly all were tested, and many once inflamed the public imagination. Today the tedious detail with which these mechanical monstrosities were worked out, and the absurd hopes that their inventors had for them are ludicrous—yet a hundred years ago they were considered a masterpiece of human ingenuity.

People worried about their appearance—so a budding genius came along with a "hat umbrella" which fitted a top hat and required no effort to hold or keep up with. Its firm grip on the crown of the hat even made it "secure in a hurricane."

Next to clothes and personal comforts our ancestors wanted to travel. The bicycle went from the plaything to the practical machine by way of several absolutely ridiculous variations. Probably the most expensive of these freak inventions were the numbers of strange ships. Some were round, some jointed, and some were designed to fly. A surprising number of them were actually built and tested.

Covering most fields of invention, this completely illustrated and brightly written book will amuse anyone interested in invention and in human foibles.

Conveyors and Related Equipment

WILBUR G. HUDSON, *M. E., ASME. Second Edition. 464 pages, 6 x 9 in. Published by John Wiley & Sons, Inc., Fourth Avenue, New York, N. Y.* $7.00.

Since this book was first published in 1944, there have been some striking developments in materials handling methods and machines. Accordingly, the author has revised the book, endeavoring to make it useful to both the student engineer and the electrical, consulting and plant engineer who must weigh intelligently the recommendation of the equipment manufacturers.

The chapters proceed through these subjects: Screw Conveyors, Flight and Apron Conveyors, The Bucket Elevator, The Skip Hoist, Bucket Carriers, Unit Loads, The Continuous-Flow Conveyor, Pneumatic and Hydraulic Conveyors, The Belt Conveyor, Aerial Tramways, Storage and Transport, Bins and Bunkers, Unloading Water-Borne Cargoes, Crushers, Hammermills and Pulverizers, Screens and Feeders, Car Unloading, Weighing, Chains, Drives, Drive Groups, Motors. Other chapters cover the handling of

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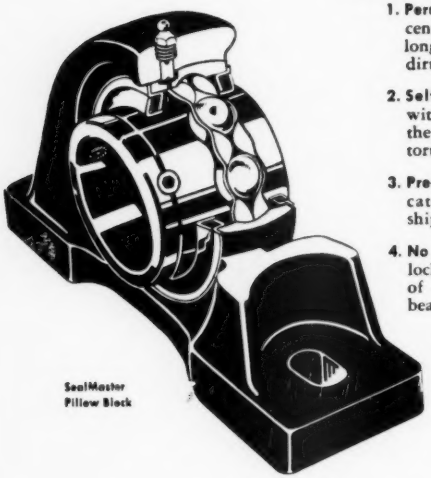

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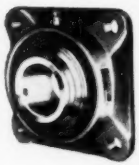

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3. Flange Cartridge Units

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coal and ash, Some Problems and Solutions, and Dust-Explosion Hazards.

The author assumes that the reader is familiar with the manufacturers' catalogues so that he has a basic understanding of the different types of equipment. In each chapter the author endeavors to give sufficient data so that one can compute the load capacity or equipment requirements. About twenty-five pages are devoted to trucks, tractors and trailers.

Tool Engineers Handbook

FRANK W. WILSON, *Editor in Chief, and the American Society of Tool Engineers Handbook Committee First edition; 2,070 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.* $15.00.

Having 115 chapters or sections, this book covers the field of tool engineering from large aspects such as product development to such detailed considerations as honing, lapping, or swaging. The authors and editors of the book have done a remarkable job of covering, in the first edition, all of the complex and detailed problems meeting today's tool or production engineers.

The authors realize that we have gone from the day of the skilled craftsman with his few machine tools, materials and methods, to an era of the unskilled and semiskilled mechanics handling many complex machines, using new and fast changing machine methods, and working with a flood of new materials. In such a fast moving technology the skilled craftsman is soon lost under the flood of changes, and the tool engineer or production expert must take over and lay out machine procedures, specify machine feeds and speeds, and plan, in detail, the entire production procedure. It is for such men that this book is written.

A great corps of editors and writers worked for three years defining the scope and limits of the material to be covered before any editorial operation started. Interviews with executives of manufacturing industries, producers of equipment and supplies, college professors, and government agencies helped to decide just what should be included in such a book. In addition, the 18,000 ASTE members were given a comprehensive survey to see what they wanted to see in this book.

With the scope defined 152 recognized authors set to work writing the book. The result is 2,070 pages of condensed, factual, interesting information on the latest developments in tool design, fabrication, maintenance, and utilization. This in-

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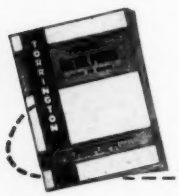

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formation is new. Right up to publication, scores of experts reviewed and checked and rechecked the definitions, symbols, equations, tables, charts, methods, illustrations, and the practices and procedures which make this the most complete book in its field.

These listed subjects cover some of the major classifications of the book:

Planning and Control of Production, Inspection and Quality.

Materials and Machinability.

Casting and Extruding Operations.

Metal Cutting; Grinding; Finishing.

Metal Forming.

Welding, Gluing and Mechanical Joining of Materials.

Surface Finish and Protective Coatings; Peening; Balancing.

Gaging; Inspection; Testing.

Fixture, Die and Tool Design; Limited-Production and Master Tooling.

Machine Tool Controls and Feeding Devices.

Design of Threads; Gears; Bearings; Springs; Other Elements.

Mathematics; Physics; Reference Tables.

Spring Problems

KARLHEINZ WALZ, *Chief Engineer, The Mauser Company, Oberndorf, Germany; translated by Bernhard Sterne.* 90 *pages,* 8¼ x 11 *in. Published by Society of Automotive Engineers,* 29 *W.* 39*th St., New York* 18, *N. Y.* $3.00 *(members),* $6.00 *(nonmembers).*

Many phases of spring design and selection not adequately covered in American publications are thoroughly discussed and integrated in this treatise on highly stressed coil springs.

As most of the investigations were carried out under impact loading to simulate actual service conditions, a special pneumatic testing machine was developed. Its working method is briefly described, and some observations are made on impact testing as it brings about some special difficulties in spring development work.

The problem of "settling," or decrease in spring length as a function of operating cycles, is of particular concern with long, low rate springs with large strokes. The significant factors affecting this phenomenon—plastic deformation, ultimate strength and crystalline structure—are discussed in detail.

Other chapters deal with heat treatment and endurance life—stress relief operations, transformation hardening, warm bath hardening, hardenability, recarburizing, nitriding,

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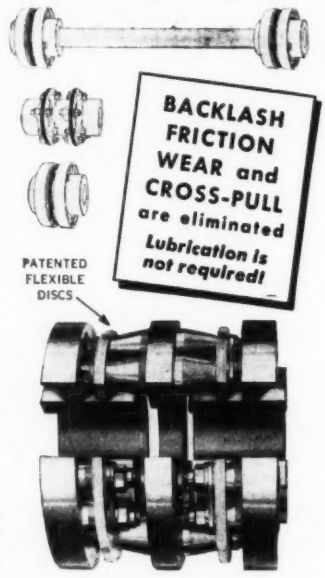

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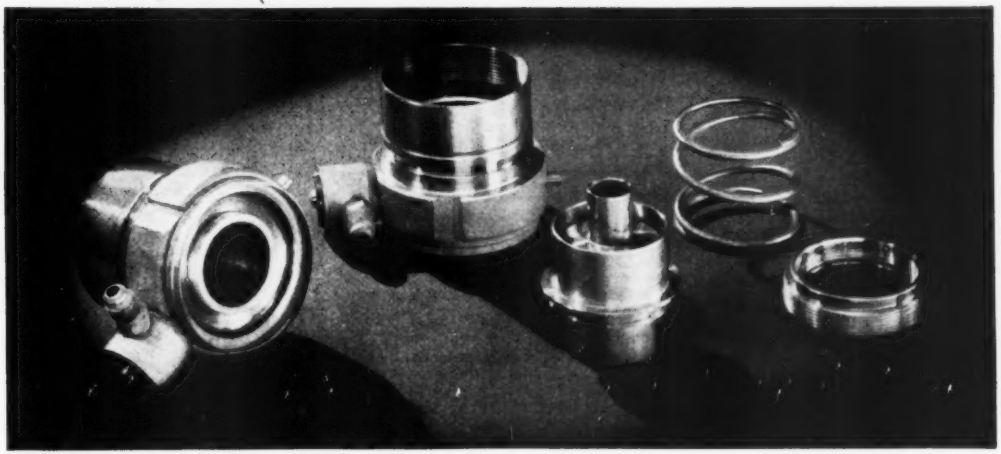

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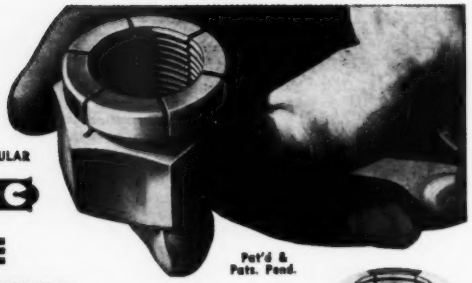

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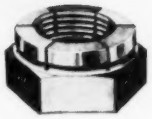

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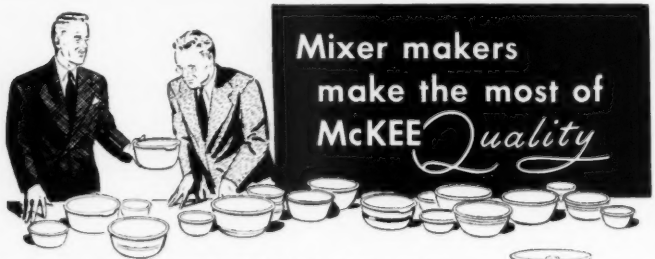

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Welding and Cutting Manual

Published by the Linde Air Products Co., 30 E. 42nd St., New York, N. Y. 204 pages, 6x9 in. $1.80.

This book will be especially useful for the home craftsman who is not already an expert in the oxy-acetylene welding and cutting process. Starting with general considerations and techniques of acetylene welding, the book then goes into special techniques to be used for particular jobs. Instructions are given in step-by-step photographs of actual repair jobs. The home craftsmen will find detailed plans for making machinery guards, trailers, shop and kitchen stools, benches, tools, picnic grills and other paraphernalia.

Heat Transfer, Vol. 1

MAX JAKOB, *Research Professor of Mechanical Engineering, Illinois Institute of Technology. First edition; 758 pages, 6 x 9 in. Published by John Wiley & Sons, Inc. New York, N. Y.* $12.00.

This text shows the development of ideas leading to the present knowledge of the heat transfer branch of thermodynamics. It is a comprehensive product of research in and teaching of heat transfer. The author uses a historical approach to the subject, covering the work done in France, Germany, England and the United States.

Part I presents the basic equations of conduction, convection and radiation. Contrary to most presentations, the author writes of all three simultaneously to accent their peculiarities and interrelationships. Following this, the most characteristic properties of conduction, convection and radiation are given with several illustrations of each. Finally, the solutions to the equations are presented. In the solutions the author treats conduction, convection, and finally radiation, in that order.

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physicists. To help readers in these fields much space has been devoted to experimental methods and techniques.

Eighteen pages of problems, thirteen pages of tables and nineteen pages of bibliography are at the end of the book. Typical chapters are: "Turbulent Flow in Tubes at Uniform Temperature," "Nucleate Boiling in Tubes," "Free Convection in Horizontal Cylinders" and "Periodic Storage and Release of Heat Energy by a Plane Plate of Finite Thickness." Taken as a whole, the book is a useful treatise for workers in this field.

Mathematics for Industry

S. E. RUSINOFF, *Assistant Professor of Mechanical Engineering, Illinois Institute of Technology.* 431 *pages,* 6 x 9 *in. Published by the American Technical Society, Chicago, Ill.* $5.50.

An extremely simple and clear book, this text presents solutions to the problems most often found in engineering shop and drafting room practice. It deals with arithmetic, algebra, geometry, trigonometry, but does not go into analytical geometry or calculus.

The foreman, machinist, draftsman and technician, as well as trade and industrial students, will find in it efficient methods of solving their technical problems. For the graduate engineer, much of the material will be elementary.

The first two chapters present a review of shop arithmetic before proceeding with the balance of the text material. Simplified algebra is treated in the following two chapters. Then follows plane geometry in the fifth and sixth chapters, which present a review of the principles of plane geometry and a brief treatment of solid geometry. Shop trigonometry and its application in the solution of problems chosen from practice are treated extensively in the seventh chapter. Chapters eight and nine treat the application of shop mathematics to screw threads and gears. The usefulness of logarithms in the solution of shop problems is described in chapter ten. The slide rule and its operation are illustrated in chapter eleven. Chapter twelve, which is the last chapter, demonstrates the application of simplified mathematics in problems dealing with engineering computations, including strength of material. The chapters end with extensive practice problems on the subject covered in that chapter. The book ends with a great number of useful tables including trigonometric functions and common logarithms. An answer book of 30 pages is included with each book.

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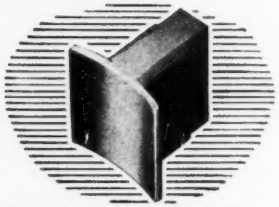

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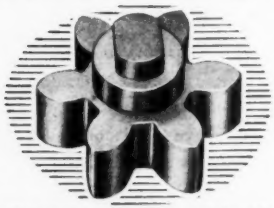

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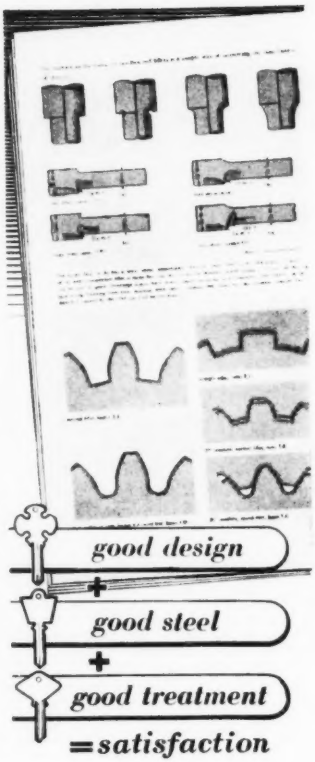

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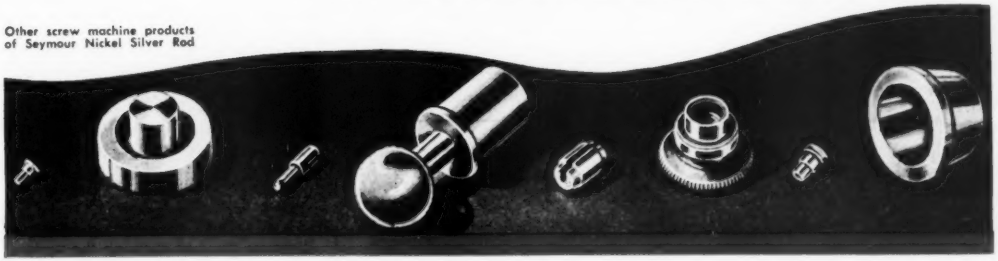

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Physical Properties Influenced By As-Quenched Hardness

Hardenability Subcommittee of the SAE War Engineering Board's Iron & Steel Technical Committee. 44 *pages,* 8½x11 *in. Published by SAE,* 29 *West* 39*th St., New York* 18, *N. Y.* $2 *non-members,* $1 *members.*

This report is the result of an investigation to determine the effect of variations in as-quenched hardness on the tensile, endurance, and impact properties after tempering several steels.

Three steels, 1345, 13T45, and 4140 were selected for this investigation on the basis of having similar carbon contents, widely different hardenability, and the fact that the relatively high hardenability of the 13T45 steel was derived from special addition agents.

Samples were quenched to hardnesses of Rockwell C 40, 47 and 55 and subsequently tempered to Rockwell C 35, for each grade of steel. These samples were rough machined prior to heat-treating to form blanks for test bars. Heat-treated blanks were finish machined and tensile, endurance and impact tests were conducted on all grades and heat-treatments. Microstructures representative of each heat-treatment were studied in relation to the physical tests.

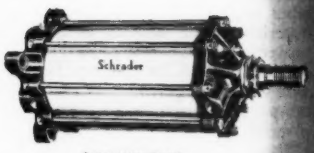
The body of the report is a discussion of the materials tested and their heat-treatment, preparation of test blanks, and an interpretation of test results. Graphs of test results and plates showing microstructures of hardened and quenched materials are included.

Strength of Metal Aircraft Elements

Prepared by a subcommittee of the Munitions Board Aircraft Committee, 109 *pages,* 8x11 *in. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.* $1.25.

Engineering reference material needed for calculating allowable stresses or minimum strengths of aircraft components is presented completely in this volume. It has been compiled for use as a handbook by designers of both civil and military type aircraft.

The book deals only with the most commonly used materials and elements. Of the five chapters in the book, four are devoted to materials. Steel, aluminum alloys, and magnesium alloys are treated extensively. Miscellaneous metals are treated to a small degree. Tables and curves amply illustrate the text showing the various



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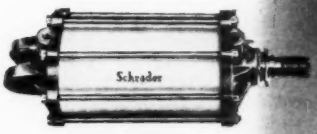

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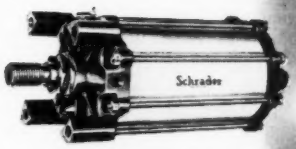

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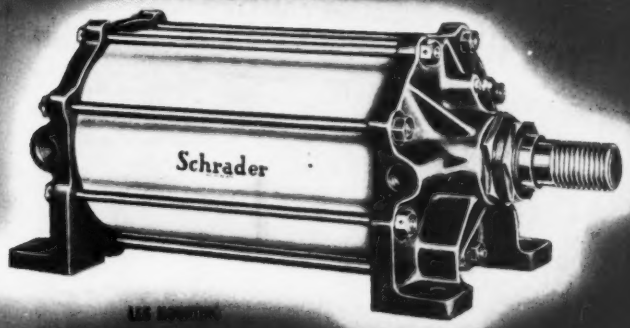

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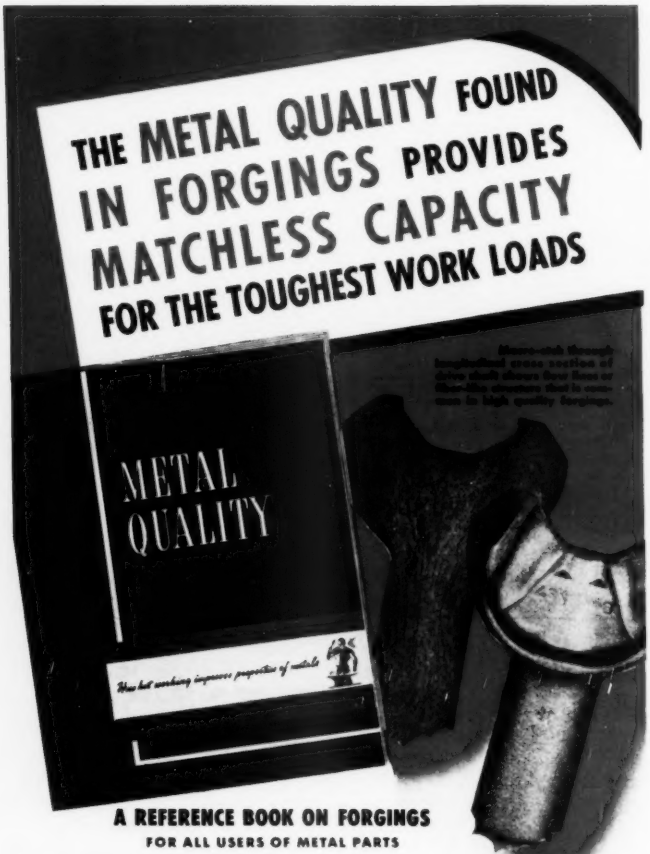

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ultimate strengths, yield strengths and other engineering properties of the materials. Such subjects as general properties of the materials, loading curves and tables for columns, beams, combined loadings, and joints, fittings, and parts are given for all three types of metal.

The last chapter presents a short table on general strength properties and related characteristics of miscellaneous metals at room temperature. Included are: Aluminum bronze, manganese bronze, hydraulic bronze and phosphor bronze.

The first chapter gives commonly used formulas and methods for calculating the strength of various structural components. Standard structural symbols and definitions are listed. A lengthy discussion on columns, with formulas and curves follows. It includes discussions on stresses, instability, failure and types of cross sections.

Technical Drawing

FREDERICK E. GIESECKE, ALVA MITCHELL, HENRY CECIL SPENCER. *Third edition, 850 pages, 6x9 in. Published by the Macmillan Co., 60 Fifth Ave., New York.* $4.50.

A basic text in engineering drawing, this book gives the new practices and procedures. The latest commercial drawings are used wherever possible.

It is not a reprinting, but a complete revision of the second edition. Much of the text has been rewritten. A considerable number of new illustrations and problems have been added, and several hundred of the old ones have been redrawn. Throughout this book has been brought into agreement with the latest revision of the American Standard Drawings and Drafting Room Practice. A complete facsimile of this Standard is given in the appendix.

Over half the page area of the book is taken up by drawings. This large area is due not only to the fact that there are well over 1,000 figures, but also to the careful elimination of all "eye-killers". The aim was to reproduce every drawing large enough to be read with ease.

A special effort has been made to place illustrations and related text matter on the same page, or on facing pages. All instructions for problems are given directly adjacent to figures.

The basic chapters on Lettering, Multi-view drawing, Sectioning, Auxiliary views, and Dimensioning are completely rewritten and expanded. Special attention has been given to the problems of the left-handed student.

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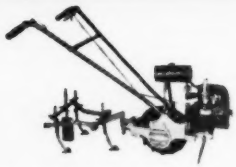

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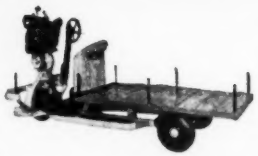

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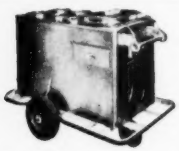
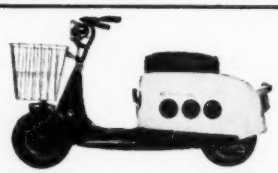


Wide-Base Generals roll smoothly, silently, protect floors and floor coverings on food carts by Swartzbaugh Mfg., Toledo, Ohio.



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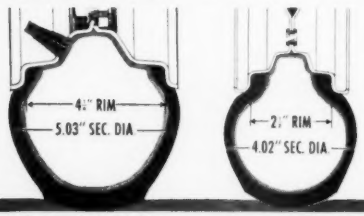

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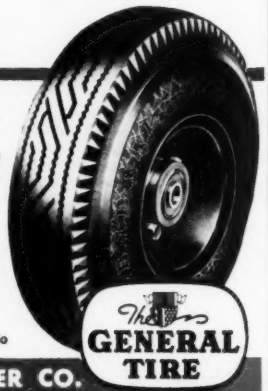

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ing. This chapter has been approximately doubled in size, with special attention given to limit dimensioning.

Many other important revisions, together with extremely complete appendices makes this a worthwhile book for teaching the language of the engineer.

Electric Eye Circuits and Relays

A. EDELMAN, *chief engineer, Photobell Co. First Edition.* 36 *pages,* 8½x10¾ *in. Published by EBY Specialty Sales Co.* 220 *E.* 23*rd St., New York, N. Y.* $1.

This is a privately printed treatise on the characteristics, types of circuits, and applications of photoelectric tubes and relays. It has been written to help the average radio man, engineer, designer, electrician and student who will find it possible to build and use photorelays, employing equipment that is available in the present-day market. The author believes that the explanations presented are sufficient so that the product designer can apply photorelays to almost any automatic control problem.

The second chapter discusses Light Sensitive Elements, including the photo-conductive cell, the photo-emissive tube, the multiplier type phototube and the photo-voltaic cell. Light Projectors and Optical Systems are discussed in Chapter 3 and 4. Types of Amplifiers, and Power Supplies are then analyzed. Chapter 8 covers Stability, Permanence and Maintenance, including such things as overall age effects, overall temperature effects and general maintenance needs. The last chapter covers Typical Circuits. This is an excellent compilation of data on this subject from the viewpoint of the product designer. For the theory underlying many of these parts, it is desirable that the reader consult textbooks.

It has been the author's objective to prepare a practical treatise that would enable the product designer to develop and apply his own photoelectric controls.

Process Control of Brass And Bronze Foundry Procedure

Brass and Bronze Castings Subcommittee, Non-Ferrous Metals Technical Committee of the SAE Technical Board. 100 *pages,* 8½x11 *in. Published by SAE.* 29 *West* 39*th St., New York* 18, *N. Y.* $4 *non-members,* $2 *members.*

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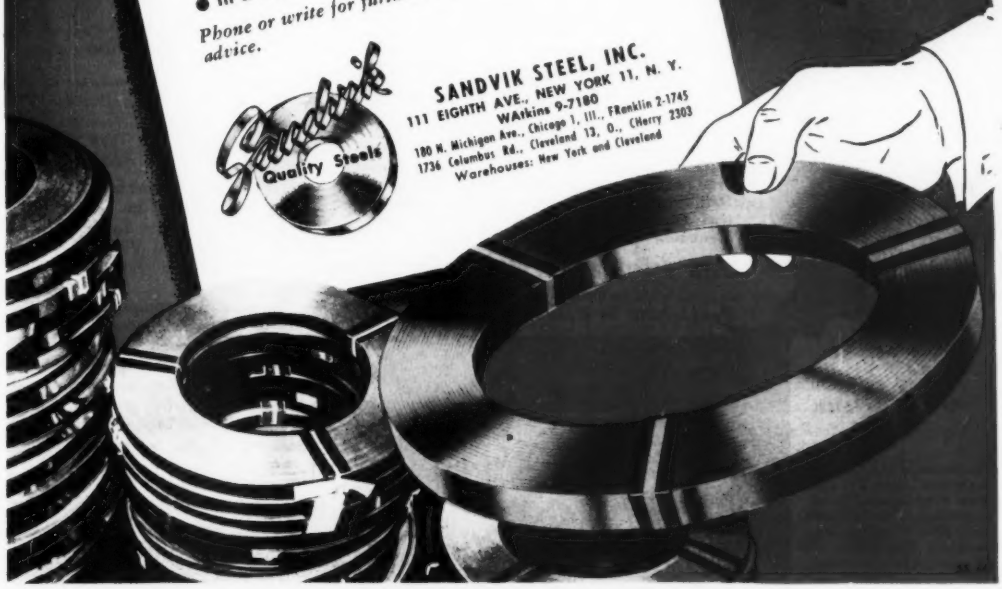

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ciated with methods and procedures. Scores of new foundries thrust into the brass and bronze castings business had to work out their own salvation or look to a few foundries of long standing for leadership in providing the most acceptable foundry technique.

An acceptable guide for insuring the control of brass and bronze procedures was lacking. This volume is designed to fill that void.

In view of the acceptance of the recommendations contained in this report by so many of the brass and bronze casting industry's leading authorities, the brass and bronze foundries should find the material contained in this report of great help in working out the details of problems that others have had to solve step by step with cut and try methods.

The Sub-Committee's recommendations cover applications, composition and properties of brass and bronze casting alloys; test bar practices; foundry molding and core sand; alloying and melting of copper, brasses, and bronzes; sand casting; centrifugal casting; pressure casting; plaster mold casting method; reclamation of castings by repairs; and inspection specifications and procedures.

The book is the result of two years' work by the Sub-Committee in reviewing and coordinating the best methods that could be found for controlling the procedure in brass and bronze foundries to obtain uniformity in the quality of castings.

Evaluation of Effects Of Torsional Vibration

Torsional Vibration Committee of the SAE War Engineering Board. 578 *pages,* 8½x11 *in. Published by SAE.* 29 *West* 39*th St., New York* 18, *N. Y.* $10 *non-members,* $5 *members.*

Scope of this volume is indicated by its complete title "The Development of Improved Means for Evaluating Effects of Torsional Vibration in Internal Combustion Engine Installations."

The book was compiled to fill the great need for a concerted effort to amplify the present knowledge, to identify reliable techniques now in use, and to develop additional techniques as required to provide a more adequate and if possible simplified treatment of the torsional vibration problem.

Several methods utilized in dealing with torsional vibration problems are reviewed. These include analytical treatments for determining torsional vibration with and without aid of actual test measurements. Instrumentations, stress determination procedures

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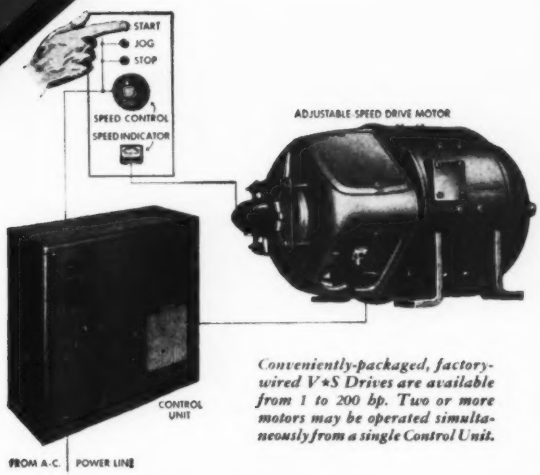

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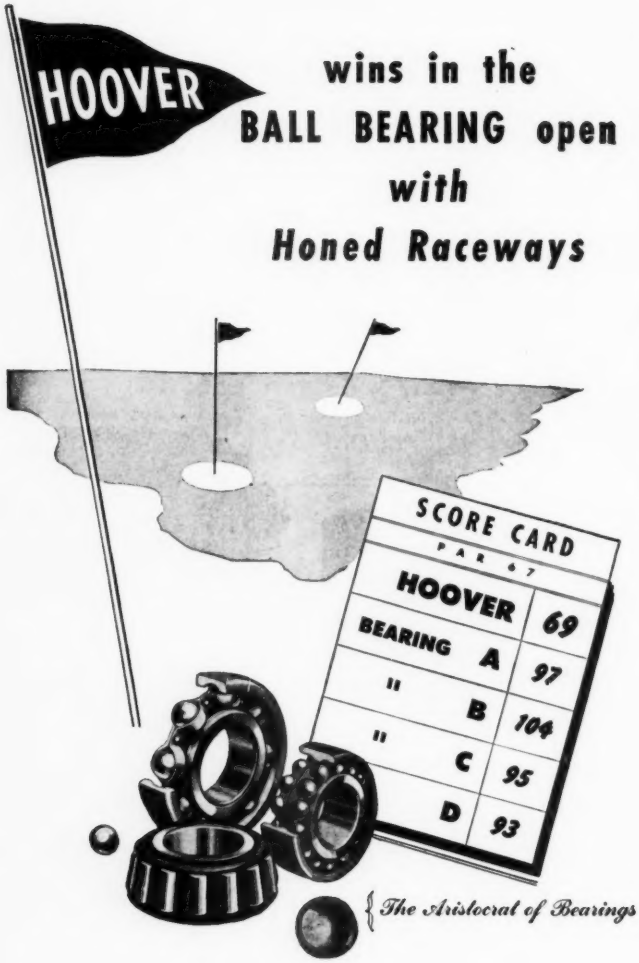

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and design treatments, including damper applications, are discussed in considerable detail. Instrument specifications are suggested. Modified concepts in the direction of more practical procedures needed to improve and, where possible, to simplify the evaluations are indicated.

The general subject matter presented may be summarized under five topical divisions as follows: (1) Methods for calculating probable natural frequencies, amplitudes and stresses of torsional vibration prior to or independent of tests of the actual installation; (2) Instrumentations for measuring amplitudes of torsional vibration; (3) Techniques for evaluating nominal stresses from measurements of the amplitudes of torsional vibration; (4) Factors influencing the localized stress caused by torsional vibration; and (5) Factors influencing the total combined stress at any small area resulting from all modes of external loading.

ABSTRACTS

Flame Spraying Steel On Light-Metal Alloys

From "Flame Spraying Steel on Aluminum," *Metallurgia* (Manchester, England), Vol. 39, No. 234, page 342

DURING THE PAST FEW YEARS, considerable experimental work has been conducted in connection with flame spraying of various grades of steel on light alloys such as aluminum and magnesium. Studies have been made using steels ranging from the soft mild to the high carbon compositions, as well as 18-8 stainless.

Since 1944 a group of research studies on this subject has been carried out by a committee of the L'Aluminium Francais, la Societe Nouvelle de Metallisation. After a great deal of experimental work they have arrived at the following conclusions on the subject.

In the case of revolving components having convex surfaces, i.e., tubes and shafts, the adherence obtained is not the result of an alloying action but rather a mechanical keying with autofrettage (cold working). Concave components require preheating before spraying can take place.

The principal characteristics of the deposits are as follows:

Hardness—The deposited metal is harder than the initial steel used for flame spraying. This is the result of the rapid cooling of the steel and the

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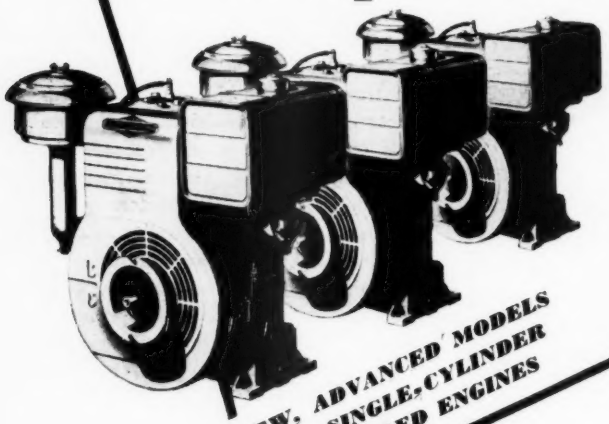

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work-hardening obtained by the crushing effect of the metal particles.

Frictional Properties—The porosity of the deposited coating affords the interesting properties of self-lubrication and anti-frictional effect. The coefficient of friction is below that of the same steel in the rolled form.

A 1-mm film of deposited steel can be regarded as impermeable despite the porosity mentioned above. The steel-light alloy couple formed does not result in electrolytic action when coverage is complete. When the base metal is only partially covered, the couple can be neutralized by a band of zinc.

Machinability—Sprayed mild steels can be machined with high speed steel tools; the cutting angles and the cutting speed should be the same as those used in machining cast iron. Steels with 0.6 percent carbon can be machined with sintered carbide cutting tools.

This new technique is particularly interesting in cases where it is necessary to lighten the weight of a component and in such cases where aluminum or magnesium could not be used because of lack of sufficient wear resistance.

Flash Losses and Cost Estimation in Die Casting

Foreign Abstract from "Cost Estimation for Diecasting" by H. K. Barton. Published in Mechanical World and Engineering Record, August 12, 1949—London, England.

LOSS OF FLASH METAL IN REMELTING, loss of pieces to wastage, and tool time costs are primary considerations in estimating die casting costs. There is a 30 percent loss of the flash metal in remelting, due to the large surface-volume ratio. To overcome this loss, it must first be estimated and then an equal amount of metal added to the initial input. Other metal from cavities, runners, sprues, and overflows is almost entirely recoverable.

Knowing the total metal required for a spray of castings, the metal throughput per hour and the melting rate can be obtained. From these calculations the cost of molten metal per pound is figured. The cost varies because the efficiency, and, hence, cost of melting varies with rate of melting.

Primary wastage due to unsound castings generally run between the 0.1 percent and 2 percent. From the records of the inspection department the average number of pieces lost due to machining can be determined. To take care of total loss due to wastage, the number of pieces equivalent to those lost are added to the produc-

MUDDLING in High Places

It is time for men in Washington and London to stop toying with the problem of international trade. We of the democratic West are at a turning point in our economic affairs. A false step by either the United States or Britain could lead quickly to disintegration of trading between the people of the world as we have known it for the past hundred years. Recent meetings of diplomats in London and Washington have not lifted us out of this danger.

By two simple tests you and I can measure the sincerity of the men in Washington and in London who are trying to solve what they call "the dollar crisis."

One test applies to the British: Is Britain making an honest effort to re-establish itself as a real competitor in world markets?

The other test applies to us in the United States: Are we willing to see Britain re-emerge as a strong competitor in world markets—even in our own home market—and to help her do so?

Today, even though both countries have faced the devaluation test, the answer to these questions probably is no.

I

The situation we face is, in fact, unprecedented. In every important industrial country of the non-Communist world, except Germany and Japan, production is above prewar volume, thanks largely to the Marshall Plan. Yet trade between nations is shackled as it has never been since the 18th century. And the shackles grow day by day. What is worse, two distinct trading areas—the dollar area and the sterling area—have grown up in the non-Communist world, and the gulf between them grows wider.

What kind of leadership have the United States and Britain had in the face of this crisis? President Truman late in August wisely checked the trans-Atlantic bickering over the dollar crisis. *But Mr. Truman showed no awareness of the basic question that the American people must soon decide: Is the United States able and willing to generate trade between nations, as Britain did in the 19th century?*

What have British leaders offered us? Foreign Secretary Bevin and Chancellor Cripps called their September visit to Washington "one of the most important missions in history." *But they did not tell the British people, and perhaps do not admit themselves, that their Labor government must change its internal and external policies if Britain is ever to earn its living in a competitive world.*

Admittedly, the problem Britain has faced since 1945 is a colossal one. But, in the face of its grave difficulties, what has Britain done? The working day was shortened. Welfare economics have run riot. High taxes have sapped incentives. Labor and capital have clung to their prewar psychology of cartels and featherbedding. Government controls and government trading have hamstrung private initiative. Nationalization schemes have injected politics into the struggle for industrial recovery.

Thus the policies of the Labor government have made Britain's adjustment to its new position in the world immensely more difficult. But Americans who attribute the danger of an international breakdown to British socialism greatly oversimplify the problem. Virtually every country in the world, socialist or not, faces the same dollar crisis that Britain faces.

continued on next page

We Americans must recognize that our economic strength unbalances world trade as does Britain's weakness. World War II increased America's superior power to produce goods. It also made the United States more self-sufficient. Thus, while the world demand for American goods has risen, our demand for foreign goods, except for basic raw materials, has not increased. Today we sell more to every major area of the world than we buy from it—and yet we wonder why there is a dollar crisis.

It is time for us to recognize that there are two fundamentally conflicting pressures at work in the United States. One is our desire for a big surplus of exports over imports. The other is our desire for a system of free-wheeling trade around the world. We can not have both unless we as taxpayers wish to subsidize our exports. Which do we want?

Curtis E. Calder, chairman of the International Relations Committee of the National Association of Manufacturers, says, "The battle of the foreign trade gap is essentially that of reconciling our urge to export our surpluses with a reluctance to accept imports in payment for them . . . The dilemma is an uncomfortable one to face."

II

Here, then, are the basic questions that confront men in Washington and London. Does Britain really want expanding world trade or a high-cost welfare state? Does the United States really want expanding world trade or a huge surplus of exports? So far politicians in Washington and especially in London have ducked these issues because they are political dynamite.

If the people of Britain decide they want to regain their position as a competitive trader in expanding world markets, here are specific objectives that men in London should set for themselves:

1. Lower government costs. The British Treasury has asked for cuts of 5% in 1950. But a cut nearer 15% will be necessary, even if that means fewer government subsidies and health services. Enterprise will never revive nor costs come down while taxes take 40% of the British national income, including roughly 60% of business profits.

2. Fewer government controls. Only by removing controls and allocations (except on a few necessities) can Britain begin to return to prices fixed by competition rather than by government fiat.

3. Stronger anti-monopoly legislation for both business and labor. Britain needs a concerted drive against all forms of restrictive, high-cost practices. This drive should put teeth in the anti-monopoly act and supplement it with legislation to end restrictions imposed by trade unions.

4. Less restrictive trading practices. Britain should retreat gradually from its international barter between governments if competition is ever to have free play in international trade.

Meanwhile, if we of the United States sincerely want multilateral world trade, men in Washington must face up to four problems and hammer out workable solutions:

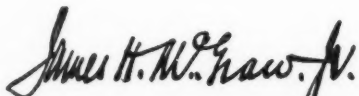
1. Use of the International Monetary Fund to back a devalued pound. In time the Fund, in which we have the controlling voice, might be used to promote convertibility of pounds into dollars.

2. Help for Britain in meeting war-created external debts. This might mean support for London in getting a reduction of the war debts Britain owes India, Pakistan and Egypt, for example. To achieve such a debt reduction for Britain we might have to underwrite a part of a Southeast Asia recovery program.

3. Encouragement of American investments abroad. Such investments should be directed primarily into enterprises which will earn dollars, such as the development of new sources of raw materials, or which will raise productivity abroad.

4. Our own tariff barriers. Our attitude toward this critical issue will be the acid test of how deeply we believe in the merits of free world competition.

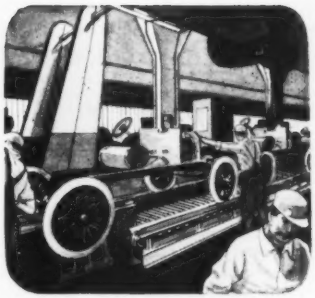
If we really want free, competitive trading between the people of the world, these issues must be met and resolved by leaders on both sides of the Atlantic. If we do not want to face these issues, then let us resign ourselves to a world walled off into three trading areas: the Communist bloc, the sterling area, and the dollar area. So far, Washington and London have muddled along, except in facing the devaluation problem. Clarity and courage are still needed.



President, McGraw-Hill Publishing Company, Inc.

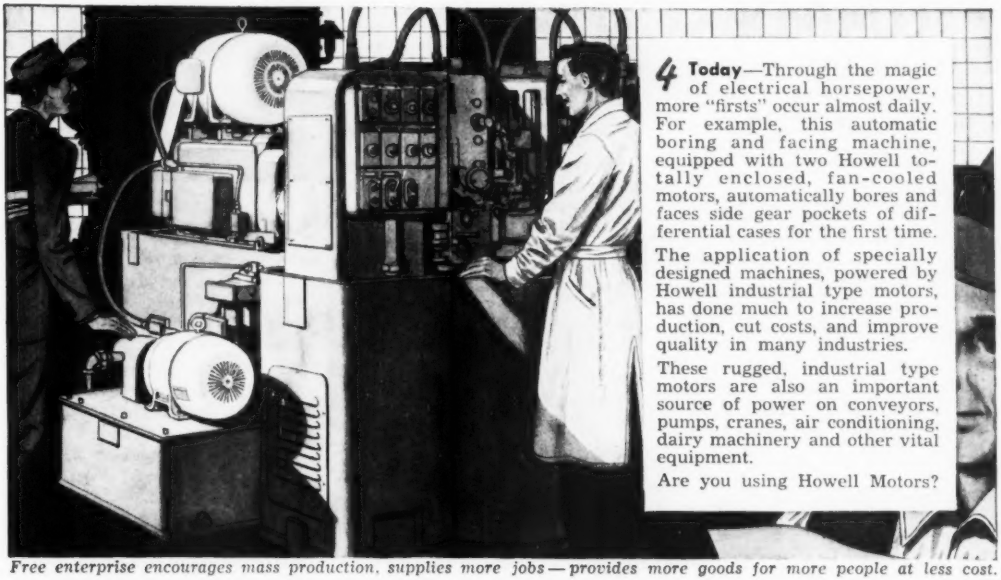
1 1875—Wisconsin offered a $10,000 reward to the person who would invent a steam carriage. George Seldon, Rochester, N. Y., was first and collected . . . America's great auto industry was under way.

2 1892—First gasoline-driven car was built by Charles Duryea with screw drivers and wrenches. Machine tools to aid this growing industry soon appeared. But parts still had to be assembled by hand.



3 1913—First moving assembly line was used in auto plants! Gone, now, was much of the labor of carrying parts. In 1915, Howell "Red Band" Motors appeared and soon were widely accepted in industry.

FAMOUS AUTOMOTIVE FIRSTS! REMEMBER?



4 Today—Through the magic of electrical horsepower, more "firsts" occur almost daily. For example, this automatic boring and facing machine, equipped with two Howell totally enclosed, fan-cooled motors, automatically bores and faces side gear pockets of differential cases for the first time.

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tion number. Thus, if total production loss is 5% for 100,000 pieces, in order to obtain 100,000 good parts, an overcast of 5,250 pieces is necessary.

Machine time needed to produce a spray is greater than it at first appears to be. Set-up and take-off time, downtime, and time needed for "proving" of tool all must be considered. Proving is often the greatest cost of these four.

One method of handling these tool time costs is to figure proving time as a percentage of the cost of the dies. However, this method obscures the fact that proving dies is not only a charge upon the tools, but also forms part of the load upon the foundry. What is considered a better method is to itemize the time required for proving in the various departments. Hence, using load charts, when the die comes in for proving, a time allowance has been made and production schedule can be kept.

The author next discusses maintenance cost of dies. One method of allowing for maintenance costs is by an averaging-out system, whereby initial tool costs are charged with a certain amount of total maintenance costs.

However, the author points out that under the averaging-out system certain tools are penalized and others are favored, because maintenance costs of various tools are different. He states the following main sources of failure common to all die casting foundries in approximate order of importance:

1. Mechanical failure of ejectors.
2. Mechanical failure of small cores.
3. Overstrain of core withdrawal and galling of core housing.
4. Accidental damage to cavity surface.
5. Mechanical failure of medium cores, sprue pins.
6. Overstrain , or distortion of ejector or core mechanism.
7. Physical failure of large cores by erosion or scoring.
8. Loss of registration between die members.
9. Erosion of sprue-hole.
10. Stripping of threads in fixing holes.

To correct the faults of the averaging out method, the author proposes a system of comparing maintenance costs of different tools.

He presents a scheme for rating different tools by points according to the degree of susceptibility to the above failures. The data for establishing the points is obtained from records of tool maintenance. With this system, proper estimation of tool maintenance costs can be secured.

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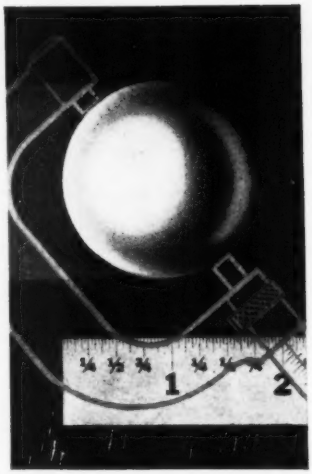

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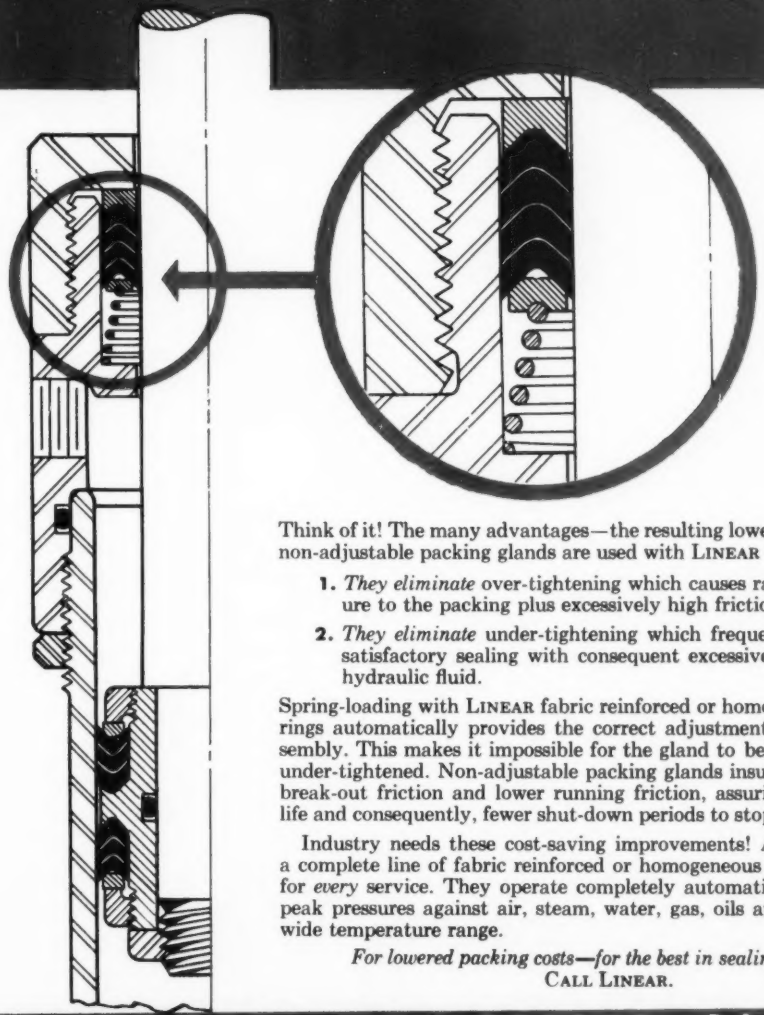

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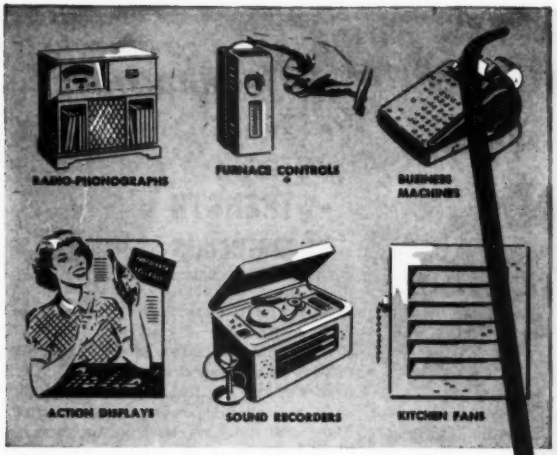

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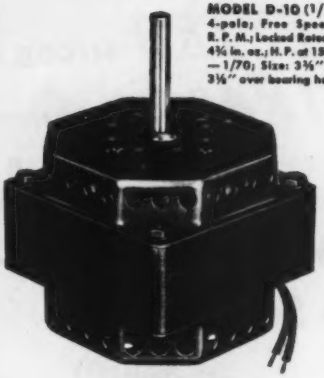

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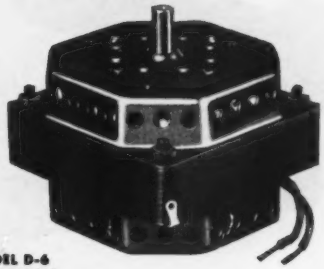

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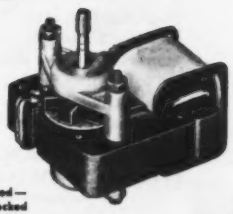
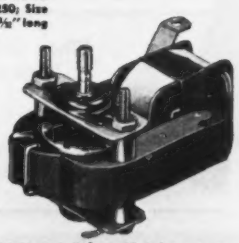


MODEL A-5 (1/250 H. P.) 2-pole; Free Speed—3470 R. P. M.; Locked Rotor Torque — 1.2 in. oz.—H. P. at 2800 R. P. M.—1/250; Size 2½" wide x 3⅛" long x 2¼" high.



MODEL C-5 (1/300 H. P.) 2-pole; Free Speed—3370 R. P. M.; Locked Rotor Torque—0.9 in. oz.—H. P. at 2600 R. P. M.—1/300; Size 2" wide x 3⅛" long x 2⅞" high.

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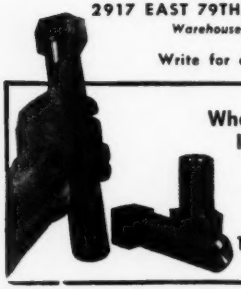

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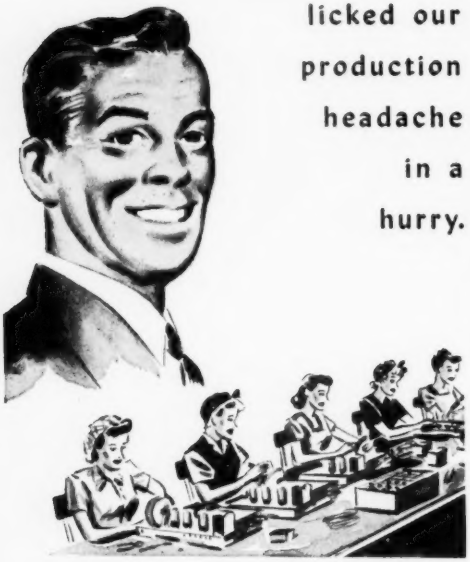

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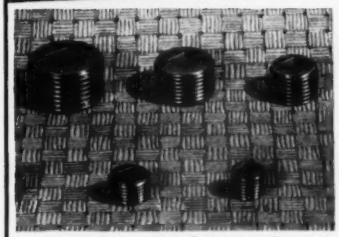

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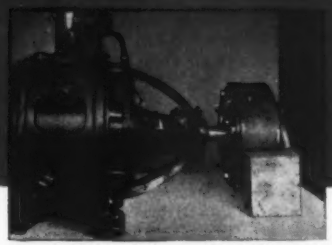
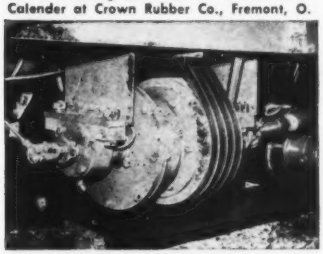
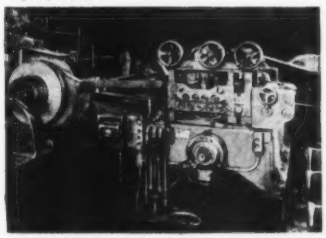
Fawick Air-Ring Clutch or Brake Type E



Fawick Air-Ring Brake on 42" x 18" Farrel Calender at Crown Rubber Co., Fremont, O.



2 Fawick Airflex elements used for auger and propel drive clutches on Self-Propel Trench Filler made by All-Purpose Spreader Co., Elyria, Ohio.



Fawick Air-Ring Slip Clutch on Dekinker at Acme Steel Company, Riverdale Works, Chicago, Illinois.

Time-wasting clutch adjustment down time is practically eliminated on Fawick-equipped machines. The moving parts of this Fawick Clutch—the rubber-and-fabric pneumatic tube and the friction shoe assemblies—adjust automatically and compensate for wear.

The smooth engagement action of this Fawick Clutch eliminates sudden shock loads which damage machinery. Controlled torque starting can be obtained with a simple modulating air valve. This type Fawick Clutch is ideally suited to continuous slip applications.

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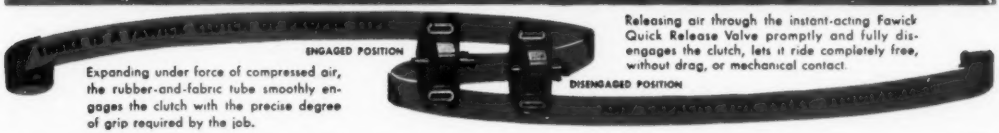

Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact.

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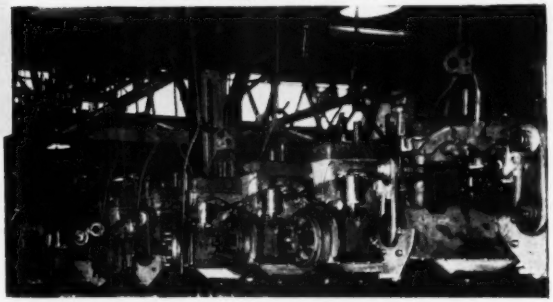
Mass Production makes Allis-Chalmers Power Units cost less to buy and to service.



-to use

A-C Power Units run inexpensively on gasoline, low-grade fuel, natural gas or butane. Their "tractor service" stamina keeps them on the job during critical work periods—avoids loss of valuable time due to shutdowns, helps build product acceptance and good will. Service facilities are nation-wide.

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ELECTRO DYNAMIC MOTORS

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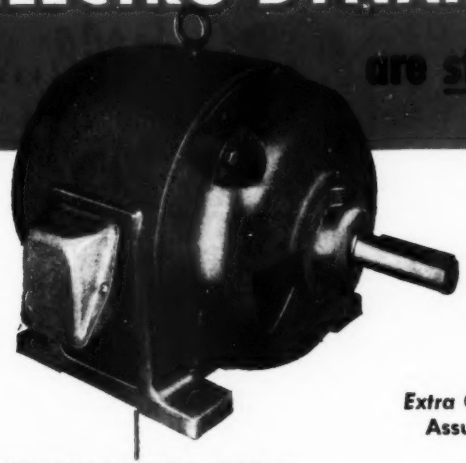

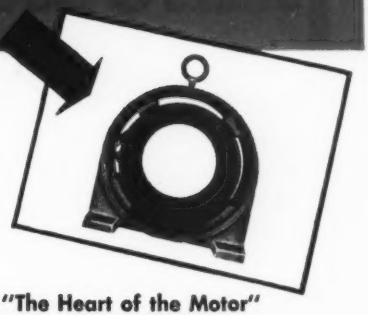

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E.D. motors have long been known for staunch dependability in the toughest of all power installations—aboard great ships at sea, under unbelievably severe operating conditions. Now the fine craftsmanship and sturdy construction features of these famous E.D. marine units have been incorporated in a versatile new line of E.D. *industrial* motors, designed to bring to *your* electric power installations the same stamina and trouble-free performance that have characterized E.D. products since 1880.

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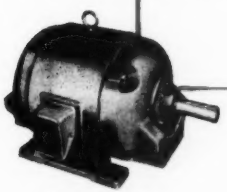

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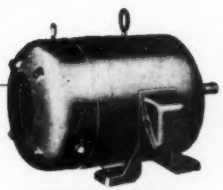
For installation where the motor is subjected to splashing liquid or hosing down for cleaning.



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For dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.

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For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

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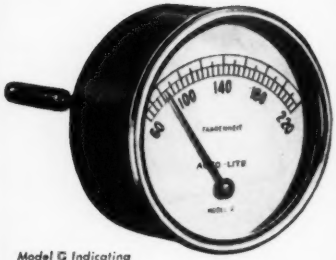

Model G Indicating Thermometer, rigid stem type; center back connection. Priced from $18.

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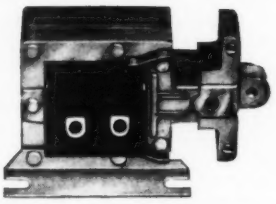

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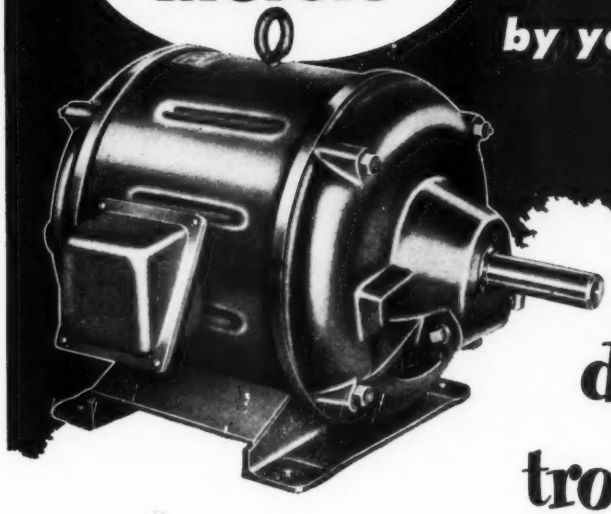

quiet... dependable... trouble-free!

Since 1930, when Wagner started manufacturing steel-frame drip-proof motors, they have been *proved*—by years of hard usage in industry after industry.

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Wagner Electric Corporation

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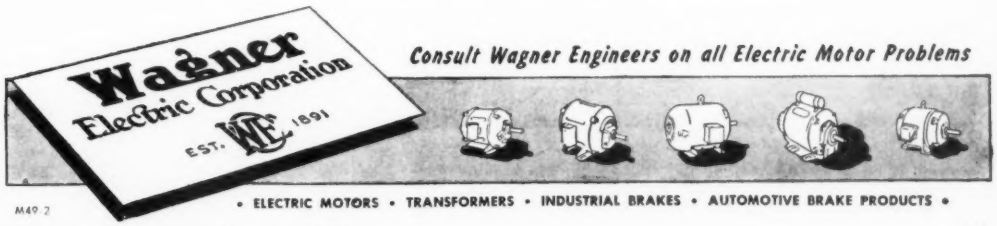
Consult Wagner Engineers on all Electric Motor Problems



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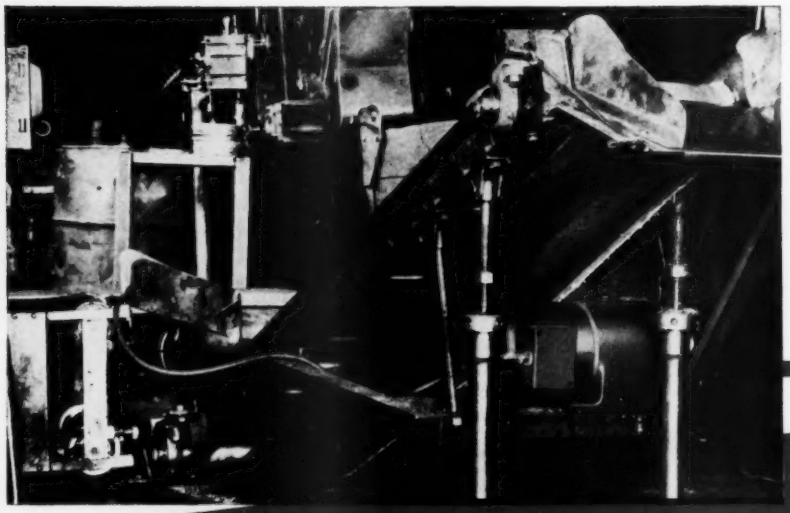


Century ¼ horsepower squirrel cage, gear motor driving a conveyor.

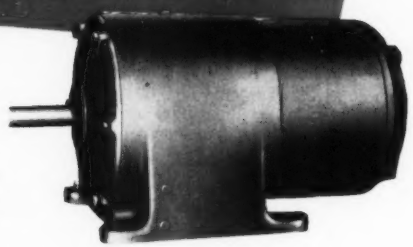
Match the Speed and Power Requirements of Your Conveyors With Century GEAR MOTORS

The conveyor shown here is driven by a Century Gear Motor which provides the correct power and speed to handle the output of a punch press.

Century Gear Motors are available in sizes from 1/6 to 1½ horsepower to provide many combinations of power and speed. The right combination on your materials handling equipment will help to coordinate your production, reduce handling costs and increase efficiency.

Century Gear Motors are engineered to maintain the high torque slow speed shaft in rigid alignment. Mounting feet are an integral part of the rugged, compact gear housing—providing a strong rigid unit.

Specify Century Gear Motors for all your slow speed requirements.



Popular types and standard ratings are generally available from factory and branch office stocks.

Century C MOTORS

-637

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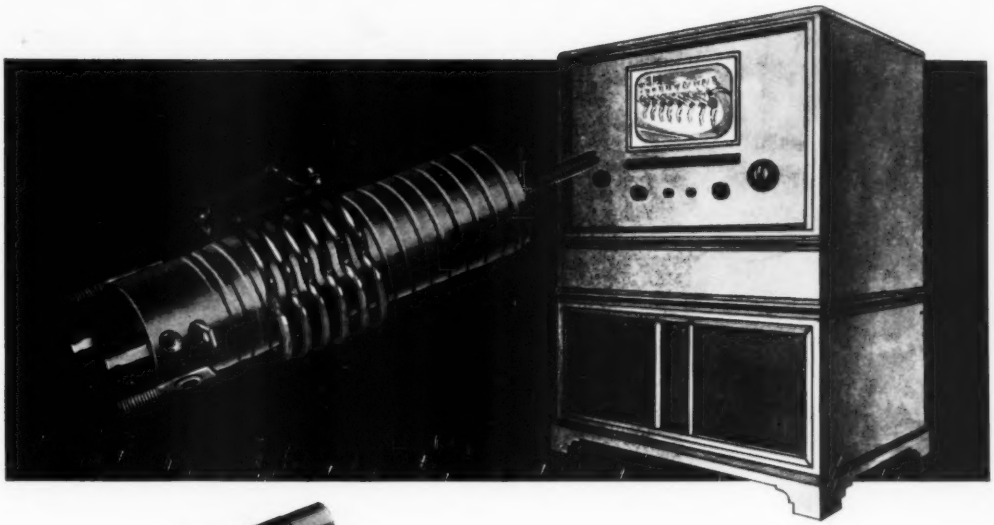
another C-D development . . .

a strong, lightweight, LOW-COST tubing for your electrical applications



Spiral Tubing—one of the many developments that have helped bring television into the mass market. Recently introduced by Continental-Diamond laboratories, it is ideal for electrical, radio, and television applications where a good dielectric tubing with high strength and lightweight is needed. It is available in a variety of sizes and grades to meet requirements for low moisture absorption, forming, riveting, drilling, tapping, etc.

It is another example of why it pays to see C-D first in your search for the right plastic. C-D Plastics provide *practical* combinations of mechanical, electrical, and chemical properties—structural strength, lightweight, moisture, heat and corrosion resistance. For fast delivery, or help with material selection problems, call your nearest C-D office, any time.

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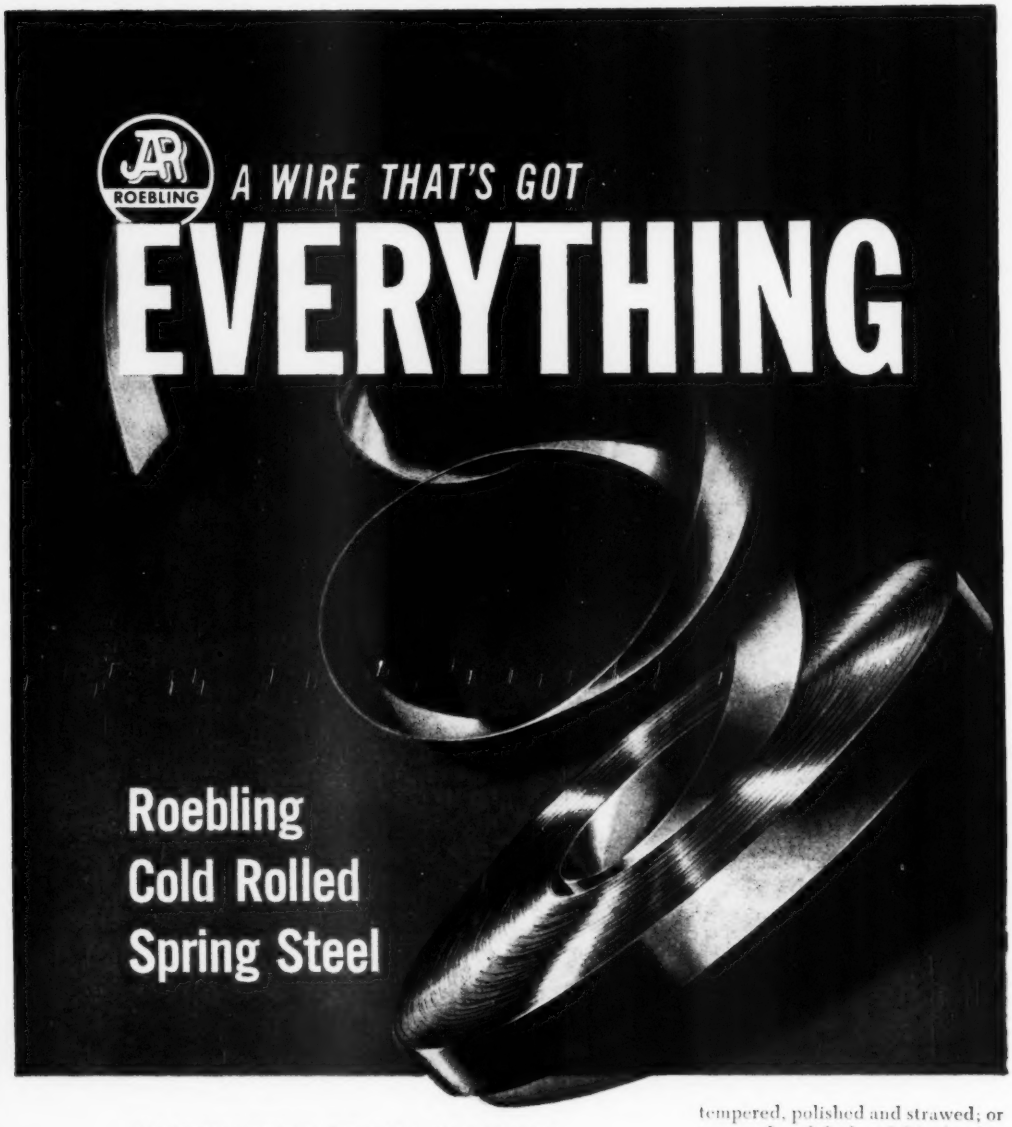

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YOU KNOW what happens when you use wire uniform in gauge, grain, analysis, temper and finish. You save time and money . . . production goes up . . . stoppages and rejects come down. And those are the reasons why more and more manufacturers are adopting Roebling Cold Rolled Spring Steel.

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3. **Efficient Arc Chutes** . . . *afford quick arc blow-out and low contact temperature.*
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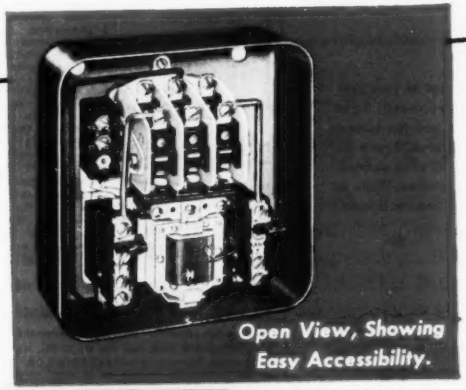
7. **Rubber Mounting** . . . *absorbs solenoid vibration through a six-layer cushion.*
8. **Easy Installation** . . . *because case is roomy and knockouts are conveniently located.*


Open View, Showing Easy Accessibility.

Honeywell Motor Starters and Contactors are compact and sturdy, designed to give long-life and maintenance-free operation. They are ideal for control panel operation . . . but are built to "take it" under the most severe conditions. The 8 reasons add up to the kind of reliability that you have to have, so specify Honeywell the next time you need Starters or Contactors.

Your local Honeywell engineer is as near as your phone. Call him in today for detailed information . . . or write for descriptive Bulletin SA1450.

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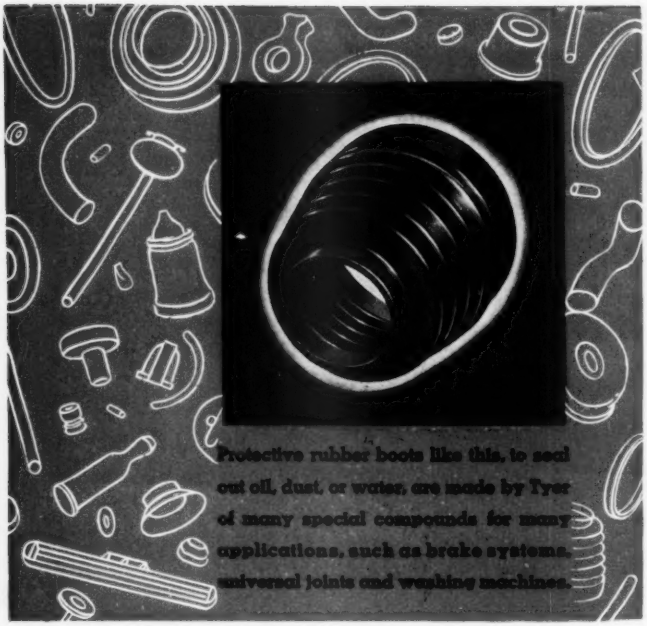
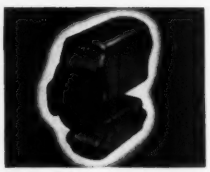


Protective rubber boots like this, to seal out oil, dust, or water, are made by Tyer of many special compounds for many applications, such as brake systems, universal joints and washing machines.

For 92 years Tyer has been doing remarkable things with rubber. Tyer originated WHITE RUBBER and ELASTIC WEBBING. Tyer's war products ranged from giant pontons to tiny earplugs made to a tolerance of one thousandth of an inch. Today Tyer leads in SERVICE to INDUSTRY. Many of the country's finest products have vital rubber parts made by Tyer. These famous manufacturers know that Tyer does unusual things with rubber.



A shock insulator made by Tyer of a high-grade, resilient, oil and weather resistant rubber compound to protect heavy trucks from road shocks.

If there is a rubber part in your product (old, new or proposed) Tyer technicians will give you the utmost cooperation in putting all Tyer's 92 years of experience at your service. Ask the Tyer representative. Write to us in Andover or to the nearest branch.

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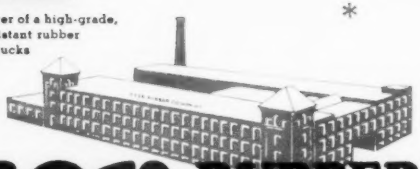

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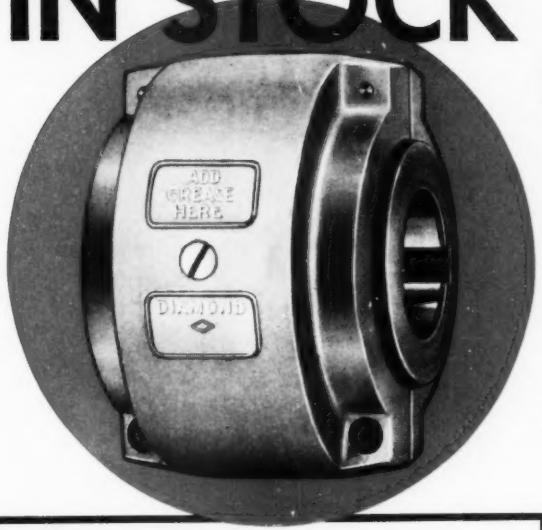

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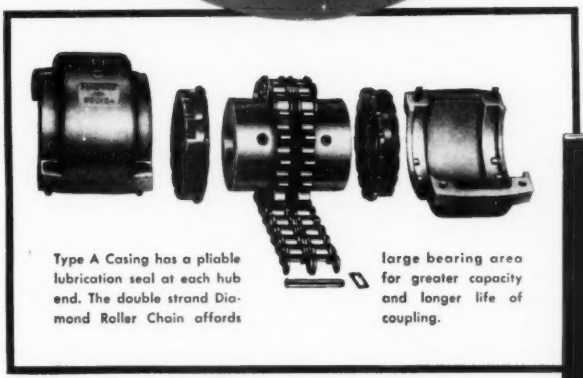

Type A Casing has a pliable lubrication seal at each hub end. The double strand Diamond Roller Chain affords large bearing area for greater capacity and longer life of coupling.

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Complete data on the enlarged Diamond Coupling Line and the strong but lightweight aluminum alloy revolving casings are included in new Bulletin No. 19. This Bulletin defines the application on various types of equipment according to character of load, horsepower and other usage conditions . . . A copy for your files will be mailed on request — write or send the coupon today. DIAMOND CHAIN COMPANY, Inc., Dept. 443, 402 Kentucky Ave., Indianapolis 7, Ind.

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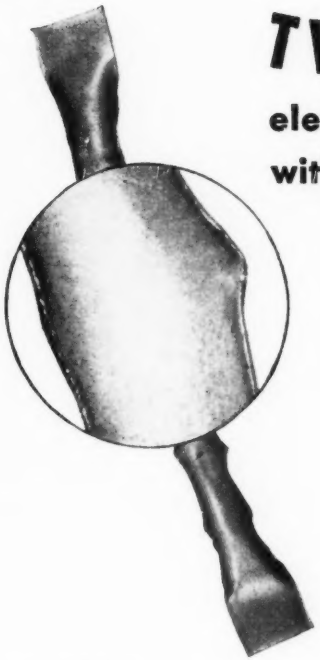
electro zinc coated THINSTEEL withstands toughest fabricating operations



The upper photograph shows how a ½" x 4½" piece of .0135" Electro Zinc Coated CMP Thinsteel was twisted tight and completely reverse twisted fifteen times. Below is shown the test sample straightened out after the fifteenth reverse twist.

The microscopic view shows a section after this gruelling test. Note that the tough, ductile, high-purity zinc coating still adheres tightly to the steel, its smooth, lustrous surface unmarred by flaking, peeling or cracking.

Here is proof that, whatever your fabricating operations, Electro Zinc Coated Thinsteel will come through unharmed.

If your product needs the corrosion resistance of a superior zinc coating — or if you can make it more attractive to the market by using zinc-coated steel, it will pay you to look further into Electro Zinc Coated CMP Thinsteel.

We'll gladly send you a sample to make your own tests.

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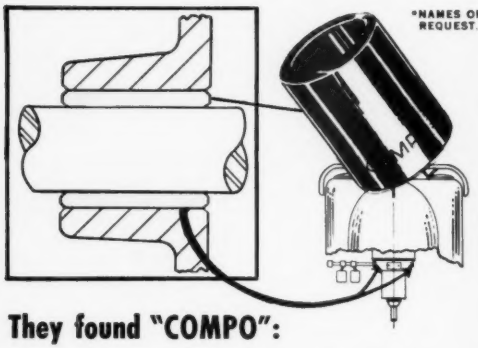
FOR CLUTCH RELEASE SHAFT BEARINGS?



*NAMES ON REQUEST.

They found "COMPO":

1. *Saved the cost of two grease fittings, the time for drilling and tapping, and eliminated the need for frequent lubrication.*
2. *Simplified design problems, speeded assembly and resulted in trouble-free operation and minimum maintenance.*

Made from pure metal powders, "COMPO" Bearings are die-formed to shape, alloyed at high temperatures, finished to exact dimensions, and vacuum-impregnated with lubricant. They can be depended upon for countless hours of trouble-free operating service. Self-lubricating qualities make them ideal for use in inaccessible spots. The lubricant is sealed in, free from dirt, and an even lubricating film is always present.

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Many types of structural parts can be made of "COMPO." On large volume requirements, their use effects great savings by eliminating machining normally needed to hold required tolerances.

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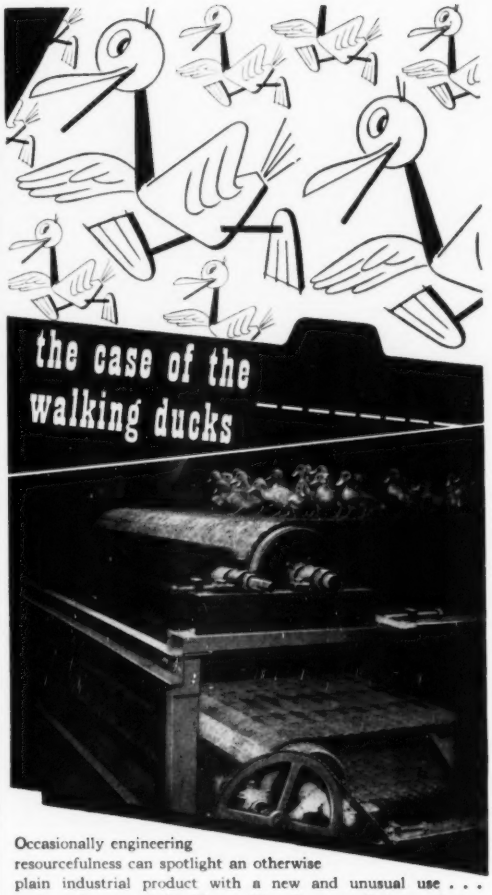

Occasionally engineering resourcefulness can spotlight an otherwise plain industrial product with a new and unusual use . . . such as the case of this Woven Wire Conveyor Belt installation in a duck brooder.

Newly hatched ducklings, it seems, have to be kept moving to be kept alive. Placed on this specially built woven wire belt moving at a slow rate of speed, the ducklings remain there for eight days . . . continually treadmilling away from the falling end of the belt. Mortality rate dropped to zero. By-product recovery . . . duck droppings for fertilizer . . . is aided by the open mesh of the woven wire belt.

Even if you don't operate a duck hatchery, call in a Cambridge engineer whenever you have a problem concerning the movement of materials or products during processing. Let him explain the superior construction features of . . .

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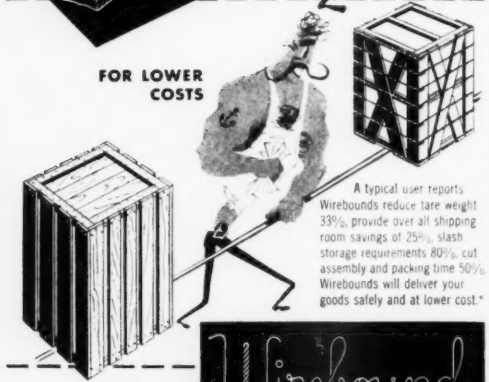

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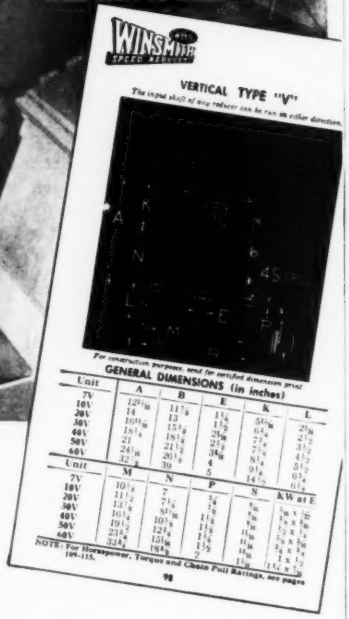


VERTICAL TYPE "V"

The input shaft of this reducer can be run in either direction.

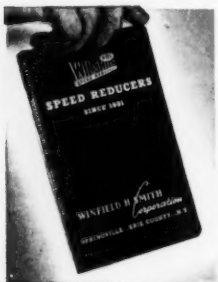
GENERAL DIMENSIONS (in inches)

Unit	A	B	E	K	L
7V	12 5/16	11 7/8	11 1/2	5 1/16	2 5/16
10V	14	11 7/8	13	6 1/2	2 1/2
20V	16 1/16	13	15 1/8	7 1/16	3 1/16
30V	18 1/2	15 1/8	17 3/8	7 15/16	3 1/16
40V	21	18 1/8	20 1/8	9 1/16	4 1/16
50V	21	21 1/8	20 1/8	9 1/16	4 1/16
60V	24 1/16	20 1/2	23 1/8	9 1/2	5 1/16

Unit	M	N	P	S	K.W. at 1
7V	10 1/2	2	3/4	9/16	1/2 x 1/4
10V	11 1/2	2 7/16	1	9/16	1/2 x 1/4
20V	13 1/2	3 1/16	1 1/8	9/16	1/2 x 1/4
30V	16 1/2	3 1/16	1 1/8	11/16	1/2 x 1/4
40V	19 1/2	3 1/16	1 1/8	11/16	1/2 x 1/4
50V	23 1/2	4 1/16	1 1/8	11/16	1/2 x 1/4
60V	23 1/2	4 1/16	1 1/8	11/16	1/2 x 1/4

NOTE: For Horsepower, Torque and Chain Pull Ratings, see pages 109-115.

On the job at the recently redesigned James H. Gray Milling Co., Franklinville, N. Y. plant, above, is one of a battery of feed mixers employing Winsmith 40V vertical type reducers. Dairy and poultry feed, in batches of 2 tons each, are thoroughly mixed by this 40V assembly in less space than ever before. The 40V and 6 other sizes of the vertical unit give a flexibility in horsepower of from .19 to 81.51 . . . and reduction ratios from 5.1-1 to 50,000-1 and up. General dimensions are shown here from a typical Winsmith 148 catalog page.



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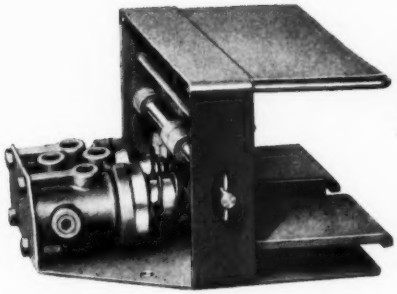

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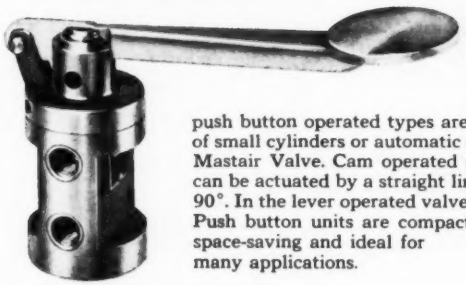

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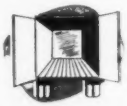
You're talking turkey to truckers when you talk extra payload capacity. That's why this trailer designer sparked when he heard that a magnesium floor  could eliminate 500 lbs. of dead weight. But his company had avoided magnesium . . . thought it was a "prima donna" metal, hard to fabricate. So he decided to get the facts for himself from Aluminum Company of America, light metal headquarters. He found that easy shop practices make handling magnesium no problem*... that every month industry utilizes over a million pounds of this featherweight metal . . . He got valuable books on designing and fabricating magnesium . . . plus the technical aid he needed. Now his company is putting the heat on competition with a strong, super-light trailer floor made of specially designed American Magnesium Extrusions.

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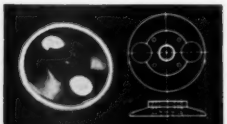

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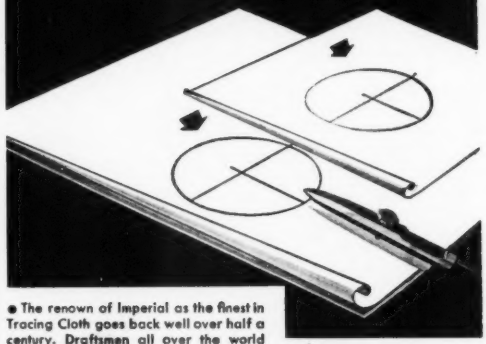

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(1) HARD RUBBER AND PLASTICS—American Hard Rubber Co., 11 Mercer St., New York 13, N. Y. Booklet, 56 pp. Gives physical, chemical and electrical properties, design techniques, sizes and shapes, fabrication procedures and typical applications of hard rubber and eight special plastic materials.

(2) METAL SCREEN—The C. O. Jelliff Mfg. Corp., Southport, Conn. Bulletin, 4 pp. Presents Lektromesh, a metal screen formed by the electro-deposition of pure copper, pure nickel, or a combination of the two. Used for filtering, electronic shielding, or as a decorative material. It comes in widths up to 36 in., lengths to 100 ft., and with from 25 to 400 strands per inch.

(3) SHIMS, LOCKNUTS, AND STAMPINGS—Laminated Shim Co., Inc., Glenbrook, Conn. Bulletin, 8 pp. Gives design details, specifications and uses of laminated shims. Also shows uses and construction of special locknut and describes the company's metal stamping facilities.

(4) TRANSMISSION BELTING—U. S. Rubber Co., Rockefeller Center, New York 20, N. Y. Catalog, 28 pp. Covers the field of flat belting, with special attention to procedures for analyzing drives and utilizing flat endless or non-endless belting. Includes a price list and two of the most common V-belts.

(5) PRESSURE GAGES—Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport, Conn. Bulletin, 16 pp. Shows construction of pressure gage which works on new principle. They use a helicoid movement instead of the usual spun gear movement to give a more accurate, more lasting instrument.

(6) COATED STEEL SHEETS—Armco Steel Corp., Middletown, Ohio. Bulletin, 12 pp. Tells how to form, join, weld, solder, clean and paint this specially coated steel sheeting.

(7) MECHANICAL PRESSURE GAGE—W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill. Bulletin, 4 pp. Shows construction and uses of this gage. It is used to measure pressures or compressive loads, not fluid pressure.

(8) ELECTRIC POWER DRIVES—Sterling Electric Motors, Los Angeles 22, Calif. Bulletin 168, 8 pp, and Data Section 70, 71, 8 pp. Shows construction details of variable speed, geared, and normal speed single phase motors. The Data Section gives full engineering information and specifications.

(9) HEAT TREATING STAINLESS STEELS—Armco Steel Corp., Middletown, Ohio. Booklet, 36 pp. Discusses general practices and equipment for heat treating chromium-nickel, ferritic chromium, and martensitic chromium types of stainless steels. Also describes methods for surface hardening and pickling. Contains many charts and graphs to summarize heat treatment information.

(10) VACUUM PUMPS—F. J. Stokes Machine Co., 5900 Tabor Rd., Philadelphia 20, Pa. Booklet, 84 pp. Shows the complete line of Stokes Microvac pumps, including specifications and applications. Also gives sample calculations for pump selection, and many typical vacuum problems with their solutions. Also has various vacuum formulas, constants and conversion factors. Includes tables and charts with engineering information on vacuum.

(11) HEAVY DUTY CASTERS — The Bassick Co., Bridgeport 2, Conn. Bulletin, 4 pp. Features line of precision-made casters with 5, 6 and 8 in. wheels, made of semi-steel, forged steel, and with rubber tread. Casters are made in both rigid and swivel types for loads up to 2,000 pounds.

(12) LAMINATED PLASTIC MATERIALS—The Formica Co., 4613 Spring Grove Ave., Cincinnati 32, Ohio. Bulletin, 16 pp. Describes Formica, a laminated thermo-setting plastic consisting essentially of fibrous sheet materials impregnated with a resin binder and pressure formed into sheets, tubes, rods and special shapes. Includes a comparison chart to show physical, electrical, and mechanical properties.

(13) A-C MOTORS—U. S. Electrical Motors, Inc., 300 E. Slauson Ave., Los Angeles 54, Calif. Bulletin 1524, 8 pp. Presents the Uniclosed Motor, a splash-proof, general purpose motor available in power ratings from ¼ to 250 hp, and having asbestos-protected windings, normalized castings, annealed laminations, and other design advantages.

(14) ALLOY STEEL PLATES—W. J. Holliday & Co., Inc., Indianapolis, Ind. Bulletin 905, 4 pp. Gives specifications and uses of Speed Alloy, a hot rolled alloy steel plate available in widths up to 72 in. and thicknesses up to 6 in. It is used for machined parts such as cams, dies, gears, racks, etc., and can be hardened up to 400 Brinell.

(15) LOCKING DEVICES—P & F. Corbin Div., The American Hardware Corp., New Britain, Conn. Catalog K296, 52 pp. Shows a complete line of locks, catches, and lock switches for doors, cabinets, show cases, meter boxes, drawers, etc. Also shows handles, hinges, lock cams, and other related hardware items. Dimensioned drawings and specifications given as well as photographs.

(16) FRACTIONAL HP MOTORS — Holtzer-Cabot, 125 Amory St., Boston 19, Mass. Bulletin, 4 pp. Describes type R-25 precision instrument motors which are available in either synchronous or induction types up to 1/500 hp, with either ball or sleeve bearings, and with built-in gear heads that provide speeds as low as one revolution per minute.

(17) BALL AND ROLLER BEARINGS—The Gwilliam Co., 360 Furman St., Brooklyn 2, N. Y. Catalog 25, 16 pp. Shows a complete line of roller and ball thrust, step, journal, and special bearings. Gives a size and price list among other specifications.

(18) ABRASION - RESISTANT ALLOY STEELS — American Brake Shoe Co., American Manganese Steel Div., Chicago Heights, Ill. Bulletin, 12 pp. Recommends alloy steels or irons for the impact

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and abrasion combination found in ball mill liners and grates. Charts and pictures describe characteristics of these alloys.

(19) SOLDERLESS WIRE TERMINALS—Aircraft-Marine Products, Inc., 1523 N. Fourth St., Harrisburg, Pa. Catalog, 22 pp. Has a "Use-A-Log" selector to aid in selection of various types of solderless wire terminals. Gives applications and fastening procedures for each type.

(20) GLASS CYLINDERS—Dunbar Glass Corp., Dunbar, W. Va. Bulletin, 6 pp. A price list of glass cylinders ranging from 1¼ to 5⅝ in. in diameter and from 4 3/16 to 15 in. in length. Cylinders are available with beaded, ground, or ground and beveled ends.

(21) COLD WORKED STEEL BARS—La Salle Steel Co., Chicago 80, Ill. Brochure, 36 pp. Discusses the metallurgical and physical properties of Stressproof steel, which is a furnace treated cold finished carbon steel bar having high strength, free machinability, minimum warpage, and good wear resistance.

(22) METAL MOLDINGS AND SHAPES—Special Products Div., Dahlstrom Metallic Door Co., Jamestown, N. Y. Catalog 9, 154 pp. Gives full size profiles of over 2,000 rolled moldings and shapes, including channels, angles, clips, panel moldings, stops, casings, mullions, glass channels, and other related shapes. Has complete index.

(23) TUBE FITTINGS—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio. Bulletin 219, 1 p. A wall chart giving the shape nomenclature of Parker industrial 3-piece tube fittings. Also gives a size table.

(24) REGULATORS, GAGES AND ADAPTERS—Air Reduction, 60 E. 42nd St., New York 17, N. Y. Catalog, 32 pp. Cutaway drawings and photos show construction and operation of regulators for hydrogen, oxygen, acetylene, and nitrogen service in a number of types. Also shows adapter, plug and chain assemblies and related gas control equipment.

(25) BEARING MATERIAL—The Wel-Met Co., Kent, Ohio. Bulletin 102, 4 pp. Lists sizes and specifications of self-lubricated bearing materials for experimental, emergency, and small lot bearings applications. Includes listing of solid and cored bars and plates.

(26) PROTECTIVE COATINGS—United Chromium, Inc. 51 E. 42nd St., New York 17, N. Y. Bulletin, 4 pp. Describes four groups of organic coatings developed for corrosion control, chemical resistance, and heavy duty industrial painting. They are adhesive, elastic, scuff resistant, and have a good surface hardness.

(27) METAL HEATING PROCESS—Selas Corp. of America, Erie Ave. and D St., Philadelphia 34, Pa. Booklet, 30 pp. Gives the complete story of Gradient heating, a fast, gas heating process. Gives a description of the method, with its advantages; the metallurgical considerations; and gradiation applied to bars, tubes, billets and strips. Also describes the process in connection with forgings, brazing, welding, indirect and patterned heat.

(28) SCREWS—United Screw and Bolt Corp., Chicago 8, Ill. Bulletin, 12 pp. Shows a line of "Clutch Head" screws with flat and oval cask heads, and hexagon, fillister, pan, and truss heads. Also lists recommended minimum hole sizes for three types of tapping screws.

(29) SYNTHETIC RESINS — Hercules Powder Co., Wilmington, Del. Catalog, 20 pp. Gives uses and physical properties of over 40 types of synthetic resins used for adhesives, binders, coatings, impregnants, printing, sizing, etc. A comprehensive, index key provides basic information, and then individual types are explained fully.

(30) FLUID MAGNETIC CLUTCHES—Duncan & Bayley, Inc., 785 Hertel Ave., Buffalo 7, N. Y. Brochure, 16 pp. Gives design features, installation, performance, applications, history, and design objectives of fluid magnetic clutches for servomechanisms. These units are essentially proportional torque controllers independent of speed.

(31) ELECTRIC PLUGS, RECEPTACLES AND CONNECTORS—Russell & Stoll Co., Inc., 125 Barclay St., New York 7, N. Y. Catalog EL 49-215, 12 pp. Shows illustrations, dimensional drawings and ordering information on automatic locking plugs, receptacles, and cord connectors.

(32) AIR MOTORS AND COMPRESSORS—Gast Mfg. Corp., Benton Harbor 2, Mich. Bulletin, 8 pp. Pictures, specifications and uses of rotary air motors, compressors and pumps for original equipment use. Motors are available in two types, four sizes, up to three horsepower.

(33) FRACTIONAL HP MOTORS — Franklin Electric Co., Inc., Bluffton, Ind. Catalog 102, 8 pp. Features motors for heating and pump industries, high torque capacitor motors, and general purpose motors. Sizes vary from ⅛ to ½ horsepower.

(34) AIR, HYDRAULIC CYLINDER CALCULATORS — Hanna Engineering Works, 1765 N. Elston Ave., Chicago 22, Ill. Two calculators. Working on slide rule principle, one calculator gives complete engineering data for selection of air cylinders and the other for hydraulic cylinders.

(35) VARIABLE SPEED DRIVES—The Master Electric Co., Dayton 1, Ohio. Brochure, 24 pp. Shows line of all metal constructed, infinitely variable speed drives in power ratings up to 3 hp, with speed ratios up to 8 to 1. Shows construction, application, and remote control operation.

(36) SPECIFYING ALLOY STEELS — Joseph T. Ryerson & Son, Inc., 16th and Rockwell Sts., Chicago, Ill. Booklet, 24 pp. Tells how to specify and buy alloy steels to guard against getting the wrong alloy, errors in heat treating, or breakdown due to use of wrong steel. Explains the end-quench hardenability test, and lists the properties of standard types of alloy and carbon steels.

(37) FLEXIBLE METALLIC HOSE—Atlantic Metal Hose Co., Inc., 122 W. 64th St., New York 23, N. Y. Catalog 100, 12 pp. Presents metallic hose made in bronze or galvanized steel. This line of hose is either the seamless or interlocking type and can be used with superheated steam, hot or cold oils, chemicals, exhaust, compressed air, or hydraulic control. Also shows couplings and flanges. Gives specifications, construction, and application.

(38) BEARING METAL—Bearium Metals Corp., Rochester 4, N. Y. Stock list, 4 pp. Shows weights of over 750 sizes of cored and solid bearing bronze bar stock up to 10 in. in diameter. Called "Bearium Metal," material is used for bearings, bushings and thrust washers.

(39) INDUSTRIAL COUNTER—Streeter-Amet Co., 4101 N. Ravenswood Ave., Chicago 13, Ill. Bulletin, 4 pp. Gives applications of counter which is actuated by an electrical pulse or signal from a contact switch, photo-tube and amplifier, or metal detector. Will also register any change in electrical intensity.

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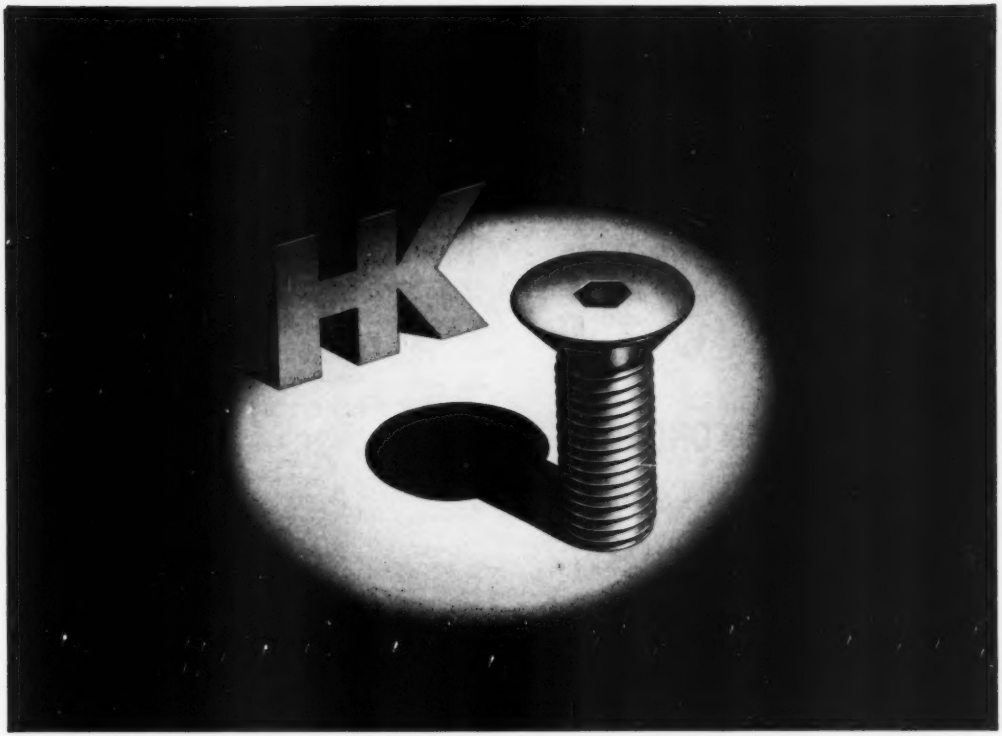

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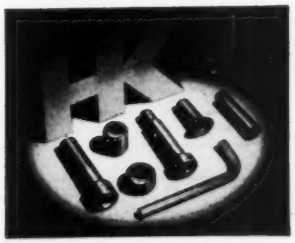

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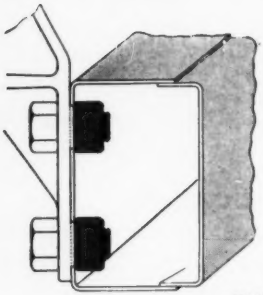

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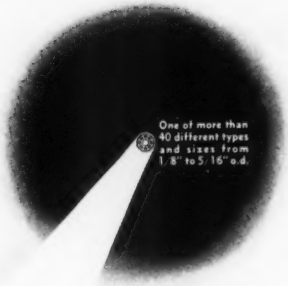

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Crystalline Structure	Hexagonal	Cubic

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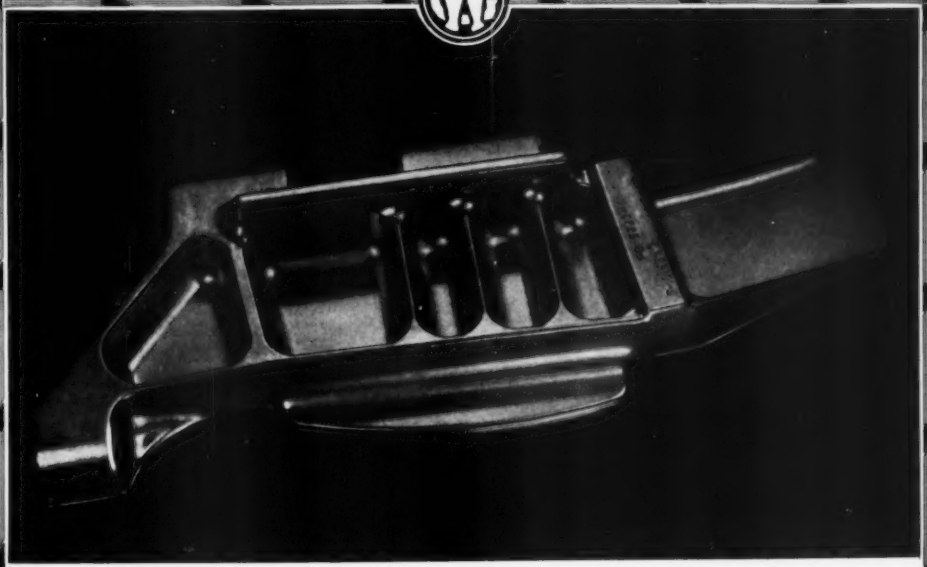

Typical of many Wyman-Gordon developments is this complicated magnesium forging used in the wing structure of one of Uncle Sam's latest fighting planes.

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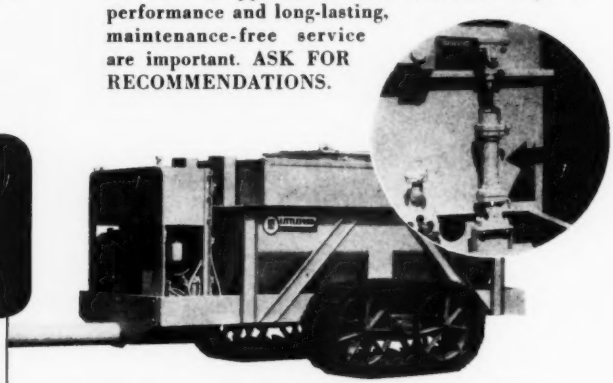

It works while you "run"! The agitator in this batch trailer built by Littleford Bros., Cincinnati, Ohio, is operated by a Hannifin hydraulic cylinder to keep the mix from hardening until used.

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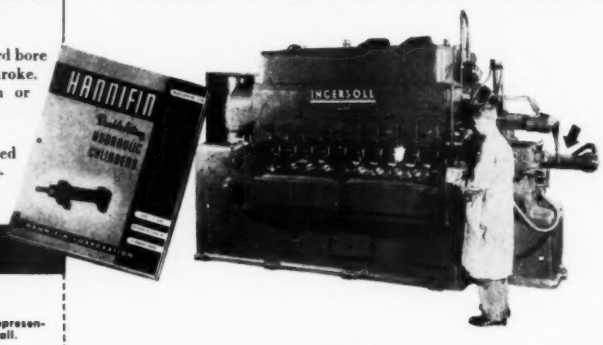

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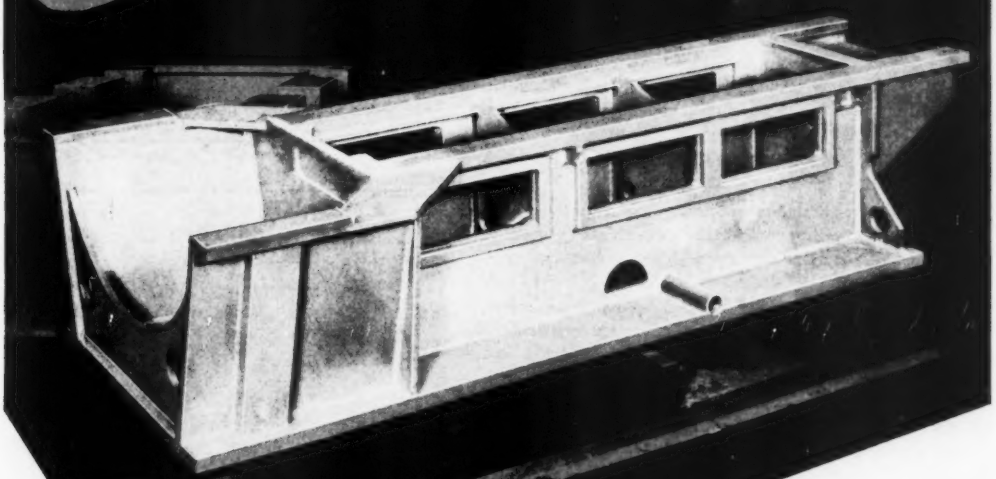

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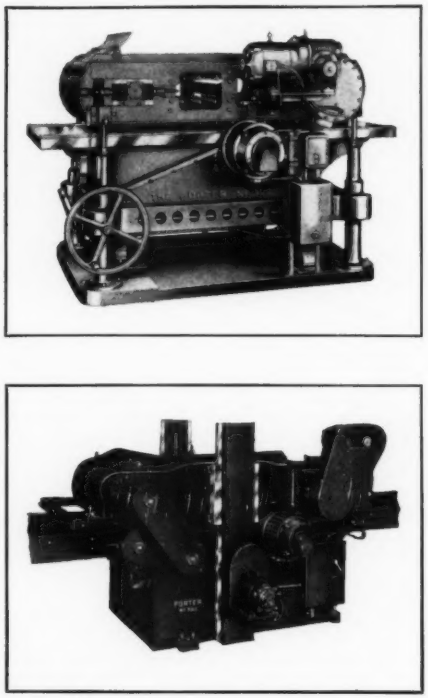

Fig. 1. Porter Facing Planer. Top: Former design showing the heavy base plate which serves no other purpose than to unify the planer and overhead feeder sections. Bottom: Welded steel design in which the rigidly braced and stiffened planer section is also the base for the overhead feed apparatus. No-purpose, costly weight has been eliminated.

Fig. 2. Left: Set-up for demonstrating rigidity of welded steel top of 36″ planer. Center: Unsupported corner of former top sags .070″. Right: Welded steel top sags only .014″.

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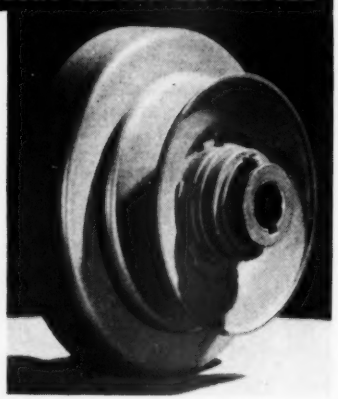

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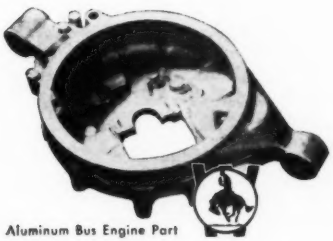

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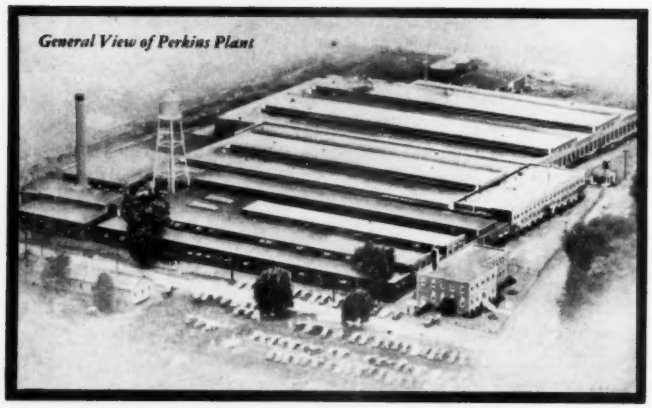

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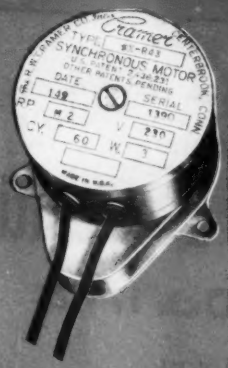

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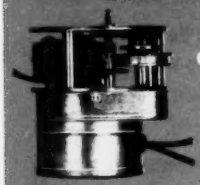

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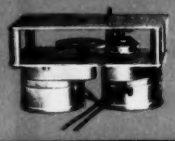

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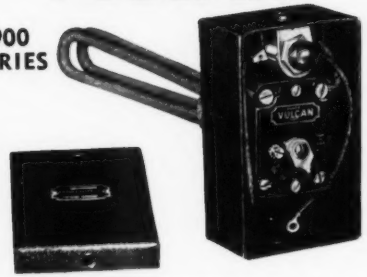

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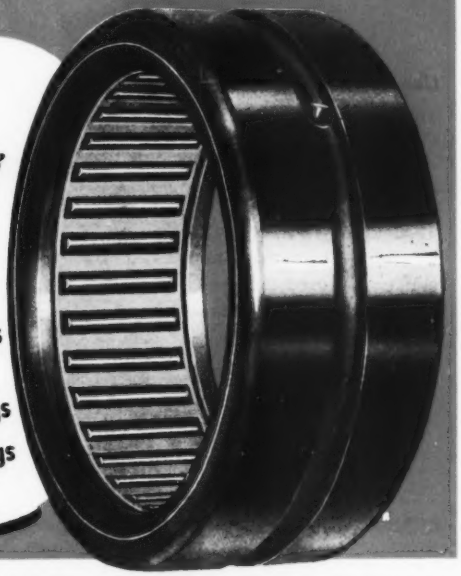

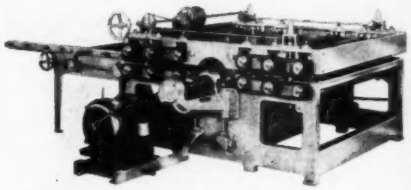

FEED ROLLS of Globe High Speed, Heavy Duty Panel Rip Saws are mounted on Orange Cage Type Needle Bearings, to meet the specifications of minimum space and high load carrying capacity. These machines are used for high speed, accurate cutting of plywood panels to size, during fabrication.

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ORANGE Cage Type Needle Bearings bring you all the compact, high-load carrying advantages of needle bearings—plus many additional features that permit you to design them safely into applications heretofore impractical for conventional needle bearings. Here's why:

The Orange cage design holds rollers in permanent alignment, preventing skewing. Internal clearances can be accurately controlled to meet exacting requirements. Square end rollers run in a free-rolling cage made of anti-friction, non-ferrous metal, having pockets coined to the curvature of the rolls. All rollers and raceways are "Pentrate" finished. These bearings run with less internal friction, are smooth and quiet in operation, have longer life expectancy.

Learn more about these unusual Orange Cage Type Needle Bearings. Write for Engineering Data Book. Consult our engineers on any application.

SEND FOR ENGINEERING DATA

showing construction, advantages, sizes, etc.

ORANGE ROLLER BEARING CO., INC.
ORANGE, NEW JERSEY

Gentlemen:

Please send me Engineering Data on new Cage Type Needle Bearings.

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551 Main Street, Orange, N. J.

A pleasant note for tubular needs

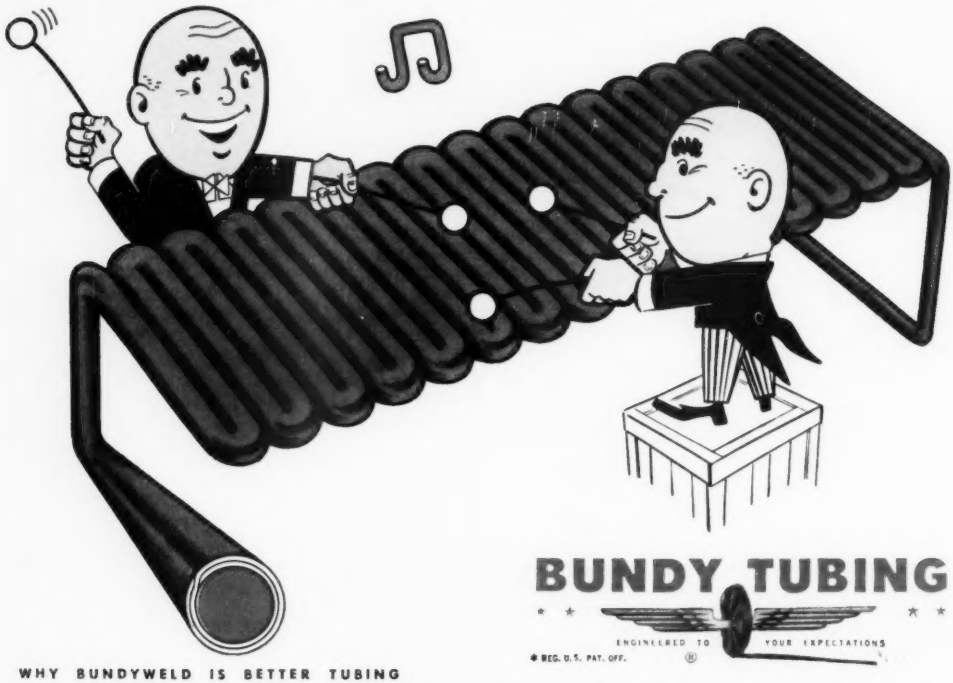
Like to add a pleasant note to your present tubular applications—a note of better design, faster production, lower costs or higher quality?

If you would, better sound out Bundyweld* Tubing!

Made of steel, Monel, or nickel by a patented process, leakproof, vibration-resistant Bundyweld is manufactured to close tolerances always. Strong yet ductile, it bends without collapsing or weakening structurally, and can be machined or fabricated easily and readily.

Tubular parts for toys, refrigeration, radiant heating, television, automobiles, machine tools, ranges . . . these are only a few of the fields that find Bundyweld ideal for their tubular needs.

If you have a tubular design or production problem, chances are that this miracle tubing of industry can strike a responsive chord in its solution. Why not give it a try? Contact your nearest Bundy representative listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*



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1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

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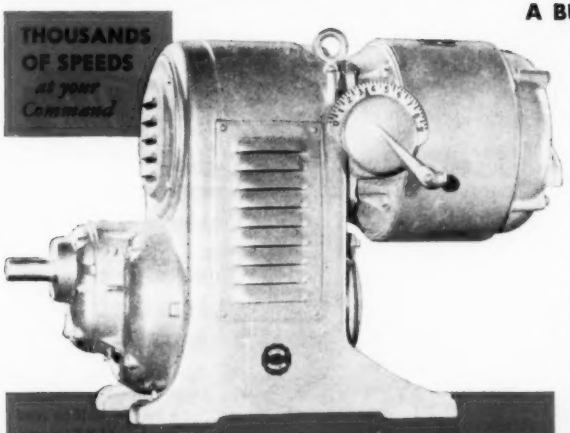
The best Investment you'll ever make

A Revelation in

CUTTING COSTS WITH VARIDRIVE

A BULLETIN FULL OF PRODUCTION FACTS



How to stimulate production with your present power machines is revealed and proved in this new, informative Bulletin. It features the improved *U.S. Varidrive Motor*—the marvel of changeable speeds. Interesting colorful illustrations show how capacities of your machines can be increased, how better quality of output can be obtained, how less fatigue of workers can be accomplished, how Varidrive can be adapted to present machines, how any selective speed can be obtained—important facts that mean the difference between profit and loss in any shop or plant. Natural color photos present Varidrive in all types and capacities. Interesting, understandable drawings show construction details. This Bulletin should be in the hands of every Production official who has the determination to cut costs without heavy investment. Ask for it.

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GIVES ANY RPM AT THE TAKE-OFF SHAFT

Instant change by turning control handle
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Most compact—little more room than a motor

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⅛ to 50 horsepower
Horizontal or upright
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Remote control optional

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STRAIN RELIEF BUSHING

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MACHINES, EQUIPMENT & APPLIANCES

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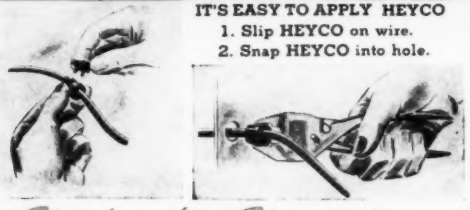
1. Slip HEYCO on wire.
2. Snap HEYCO into hole.



Here's what Heyco does-

1. Absorbs cord pull, push and torque
2. Insulates wire from chassis
3. Prevents wire from fraying
4. Eliminates tying wire knots
5. Improves product appearance at low cost

TEST SAMPLES WILL BE SENT ON RECEIPT OF WIRE SPECIFICATIONS

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In Canada approved by Canadian Standards Association No. 8919

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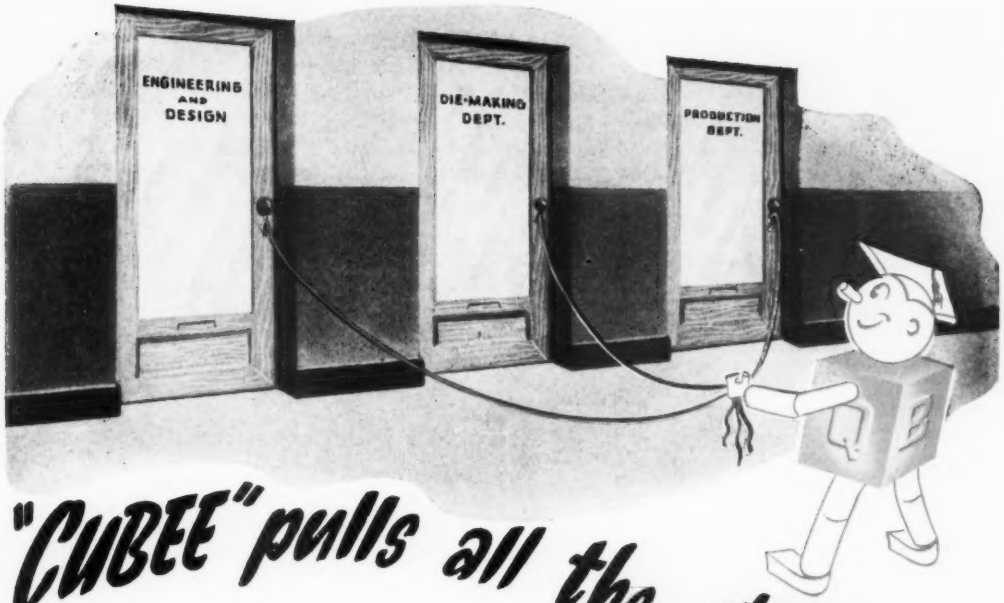
Write today for new free Bulletin No. 493 giving complete data on models and prices.

Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
132 Belden Ave., Norwalk, Conn.



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Doesn't it always simplify matters when you can "dump" a problem into someone's lap and forget it? That's why "Cubee" has a big lap. He takes complete control. All the facilities needed to supply you with molded plastics parts are under one roof . . . *our* roof. We design the molds—we make the molds—we mold the plastics product. Nothing is "farmed-out". The complete responsibility is ours. And why shouldn't it be? That's our business—Plastics! The next time you need molded plastics products, call "Cubee". We'll consult with your engineers and designers and come up with the answers to your problems.

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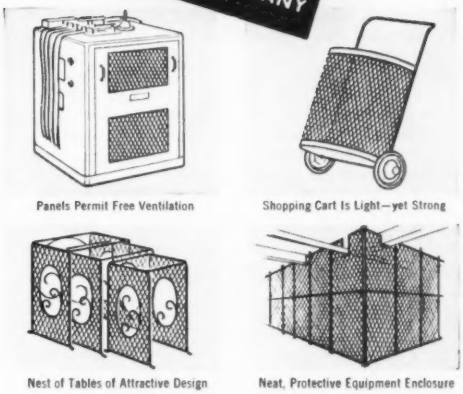

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See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900 today. It describes the complete line of Lord products and services.

LORD MANUFACTURING CO., ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp., Ltd.

LORD Vibration Control Systems

Step up the sales appeal of your product with a K-C Electric Motor

Your customers want a motor that's smart looking . . . made by a manufacturer with a reputation for high-quality electrical products.

Power your product with a K-C Motor and you give them what they want. You also assure them long and carefree service. K-C Motors can "take it." Even under tough conditions of continuous use, they run cool, smooth, quiet.

K-C Motors with the following features are suitable for a wide variety of applications:

- *Single-phase (capacitor-start and split-phase) and polyphase types.*
- *Ratings of 1/4, 1/3, 1/2, 3/4, 1 and 1 1/2 H.P.*
- *Ball or sleeve bearings.*
- *Dual voltage on all capacitor-start and polyphase units—1725 or 3450 R.P.M.*
- *Rigid or resilient mounts that meet NEMA specifications.*

NOW PRICES ARE DOWN ON THIS SPECIAL SERVICE MOTOR!

This ruggedly constructed single-phase K-C Motor is suitable for a wide variety of applications. Built in rigid or resilient mounting, with sleeve bearings for horizontal operation—ball bearings for use in any position. Available in 1/4, 1/3, or 1/2 H.P. capacitor-start and 1/4 or 1/3 H.P. split-phase (illustrated). Write for complete specifications and price quotations.

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Kingston-Conley Division
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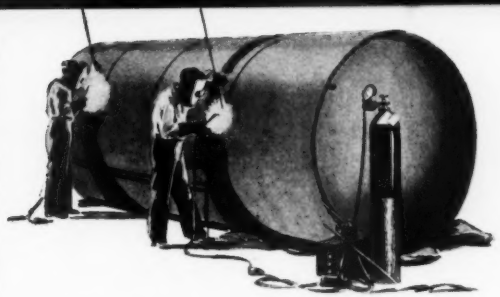

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In some coal mines, a mixture of liquid oxygen and finely divided carbon is used for blasting. This 4,000-gallon liquid oxygen storage tank was fabricated by L'Air Liquide Society, Montreal, Canada. Made of Everdur† for strength and corrosion resistance, 150 feet of seams were arc-welded by the inert-atmosphere process using water-cooled torches.

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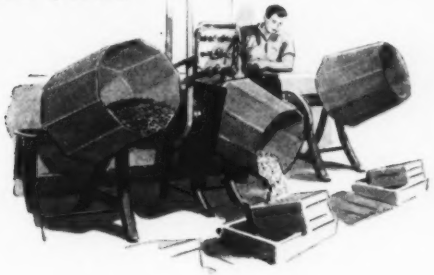
This isn't an act, it's a record—up to now—for this battery of three tumbling barrels made of Everdur. Used for wet tumbling, polishing and lustering of light metal products in corrosive solutions, they outlast wooden barrels by 20 to 1.



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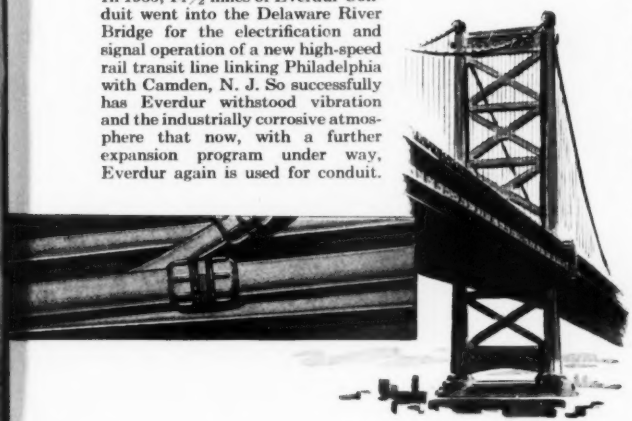
In 1935, 14½ miles of Everdur Conduit went into the Delaware River Bridge for the electrification and signal operation of a new high-speed rail transit line linking Philadelphia with Camden, N. J. So successfully has Everdur withstood vibration and the industrially corrosive atmosphere that now, with a further expansion program under way, Everdur again is used for conduit.



ONE IN A MILLION

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This isn't an ordinary bolt—it can't afford to be. It's one of uncounted millions of items collectively called "pole line hardware." Made of Everdur, they resist—for years on end—gales and storms and ever-changing temperatures; corrosive gases and vapors; humid atmospheres and saline fogs, and hold in check the anxious, surging, high-line power that forever is seeking a quick, destructive path to ground

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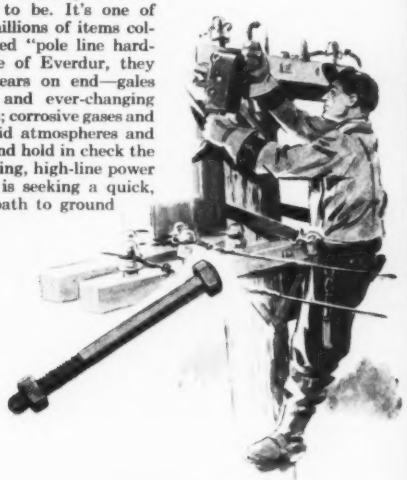

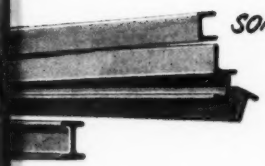

SOMETHING NEW HAS BEEN ADDED

This is just to let you know that Everdur structural shapes are now available from stock in angles, channels, Tee shapes and "I" beam sections. Address The American Brass Company, 70 Sayre Street, Buffalo 5, New York.

P.S. HOW ABOUT SENDING IN YOUR STORY ON EVERDUR?

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Our Technical Department has a wealth of information on the properties and applications of Everdur. Write to The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 40191

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If vertical drives are your problem, consult De Laval.

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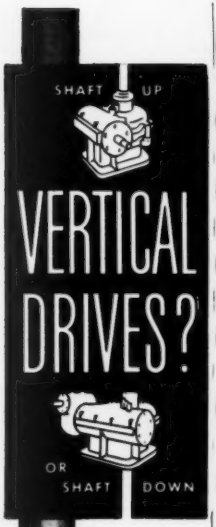

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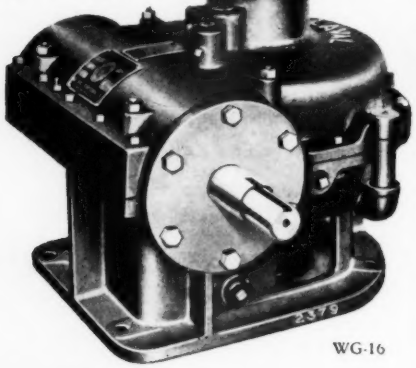

WG-16

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Boiling would be rugged treatment for any steer. But, for Sirvis steer*hide* it's a must. The boil test, which is more severe than either dry heat or hot oil tests, determines heat resistance, measured by shrinkage. Because of Sirvis tanning processes, shrinkage under the boil test is usually less than 1%. Sirvis' reaction to the test is demonstrated by two pieces of buff grain steerhide, identical in quality and dimensions. After boiling in the same container for thirty minutes, one piece, an ordinary vegetable tanned leather, was hard, curled and shrunken, as shown in the photograph. The Sirvis chrome retanned piece shrank only 0.7% . . . retained its natural flexibility, strength and texture . . . and its resistance to heat was thereby accurately determined.

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THIS Handbook brings you the most modern, authoritative data on the design, fabrication, maintenance and economical use of tools and machinery used in industry. Of importance to anyone connected with mechanical processing of finished products, it covers product design and cost estimating, the economical selection of machines, processes and tools, the analysis and improvement of set-ups and operations. Consult it for rules, formulas, procedures and useful data. Use it with complete confidence; data are based, wherever possible and practicable, on standards established by the government, the professional associations, and leading industrial companies throughout the country.

TOOL ENGINEERS HANDBOOK

American Society of Tool Engineers

Frank W. Wilson, Editor-in-Chief

Written by 144 authorities in the field, this massive reference has been checked and double-checked to insure accuracy from cover to cover. Here are the complete authoritative answers to problems you meet from day to day—brought to you in compact, easy-to-find form.

More than 2000 pages! Over 1500 illustrations! Hundreds of tables, charts, keyed diagrams, symbols, definitions, equations, etc.

A small selection of highlights selected at random to illustrate the scope of this Handbook:

—Describes types of machines, cutting tools, toolholders, fixtures and operations in precision production boring.
—Includes all new techniques and processes of recognized acceptance including Powder Metallurgy, Investment Casting, Plastic Joining of Materials, etc.
—Conventional tables of feeds, speeds and cuts modernized to bring them into line with latest cutting-tool materials and cutting practices.
—Treats, process-wise, such topics as Plaster Mold Casting, Superfinishing, Rotary Swaging, Sheet and strip cold roll forming, Die Hobbing, etc.
—Covers every phase of metal cutting and machinability.
—Discusses welding, gluing and mechanical joining of materials.

Partial Listing of the Handbook's 115 Big Sections which Cover Tool Engineering from A to Z:

- Job Planning and Control
- Small Tools Planning and Control
- General Structure and Properties of Metals
- Properties and Workability of Plastics
- Plastics Forming
- Inspection Equipment and Methods
- Investment Casting
- Milling
- Shrinkage Fits
- Broaching
- Engine Lathes
- Power Bandsawing
- Gear Shaping
- Jigs and Fixtures
- Thread Chasing
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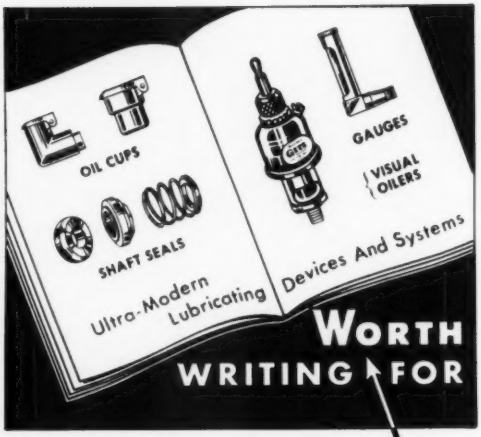

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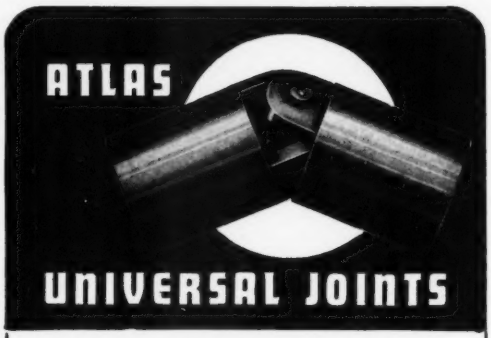

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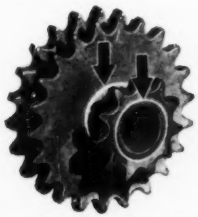
A simple way to DO something about ECONOMY-IN-PRODUCTION

EASY - FLO brazing this motorcycle handlebar instead of welding it saved 8¢ per assembly — a saving that grows big when you multiply it by thousands of assemblies.

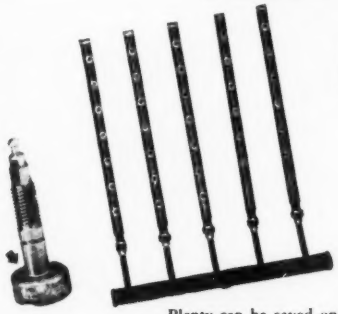
Everybody is talking about economy-in-production. It's the keynote of the Metal Show to be held in Cleveland, October 17 to 21. But what counts most is *doing* something about it. In some cases, of course, that's not always so easy. There are, however, hundreds of fabricating operations where economy could be quickly effected by using methods which can be readily adopted.

One such method that offers quick results is *EASY-FLO* and *SIL-FOS low-temperature silver alloy brazing.* It has boosted production and cut costs on thousands of products. Illustrated are a few typical tried and proved ways to

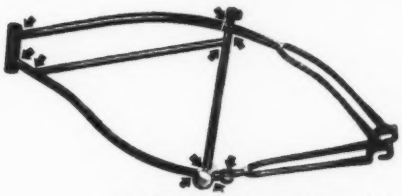
BRAZE AND SAVE WITH EASY-FLO AND SIL-FOS



Big savings are possible on many parts now machined from the solid by changing to a built-up assembly brazed with EASY FLO. The triple-sprocket above and hose nozzle adjusting part at right are good examples.



Plenty can be saved on many parts now cast, by changing to EASY-FLO or SIL-FOS brazed construction. The gas burner (above), once an iron casting, is now made of tubular Steel members EASY-FLO brazed at about 50% lower cost.



Finishing is another operation on which EASY-FLO and SIL-FOS brazing can save plenty. The maker of the EASY-FLO brazed bike frame (above) says—"This method produces joints of great strength which are absolutely clean—free from excess brazing metal—making possible a better looking enamel finish."

Attaching spuds to many types of equipment can be done faster and cheaper with EASY-FLO and SIL-FOS brazing. Using EASY-FLO and induction heating, instead of soft soldering by hand, reduced cost on the automobile oil pan spud (left) from $11.00 to $4.50 per hundred.

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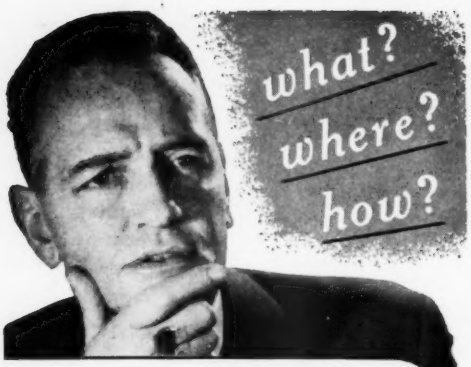

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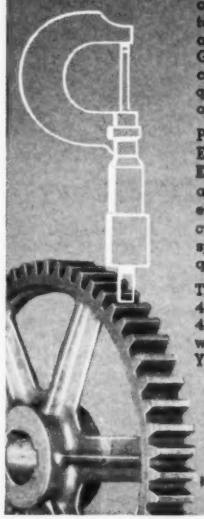

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For complete information on these *smoother-than-steam* hydraulic power transmission units, write for Twin Disc Hydraulic Torque Converter Bulletin 135-C.
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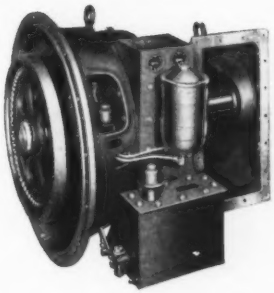
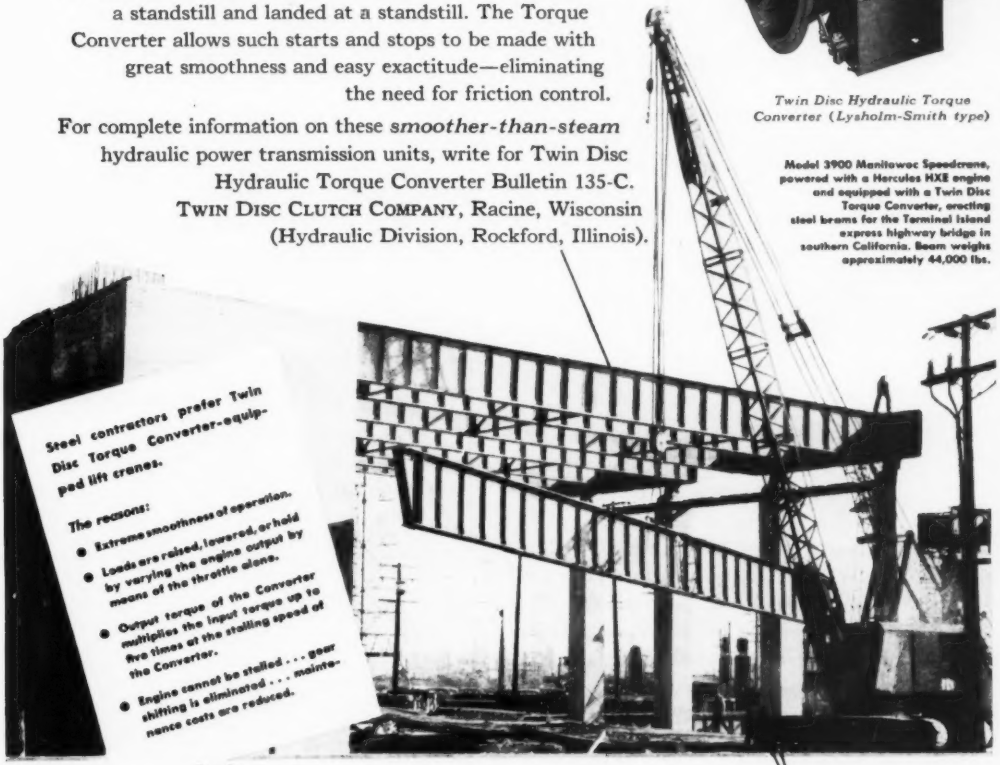


Twin Disc Hydraulic Torque Converter (Lysholm-Smith type)

Model 3900 Manitowoc Speedcrane, powered with a Hercules HXE engine and equipped with a Twin Disc Torque Converter, erecting steel beams for the Terminal Island express highway bridge in southern California. Beam weighs approximately 44,000 lbs.


Steel contractors prefer Twin Disc Torque Converter-equipped lift cranes.
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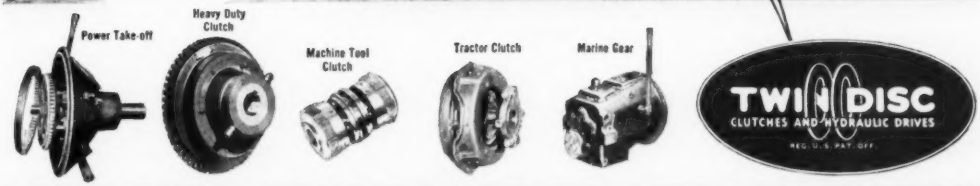

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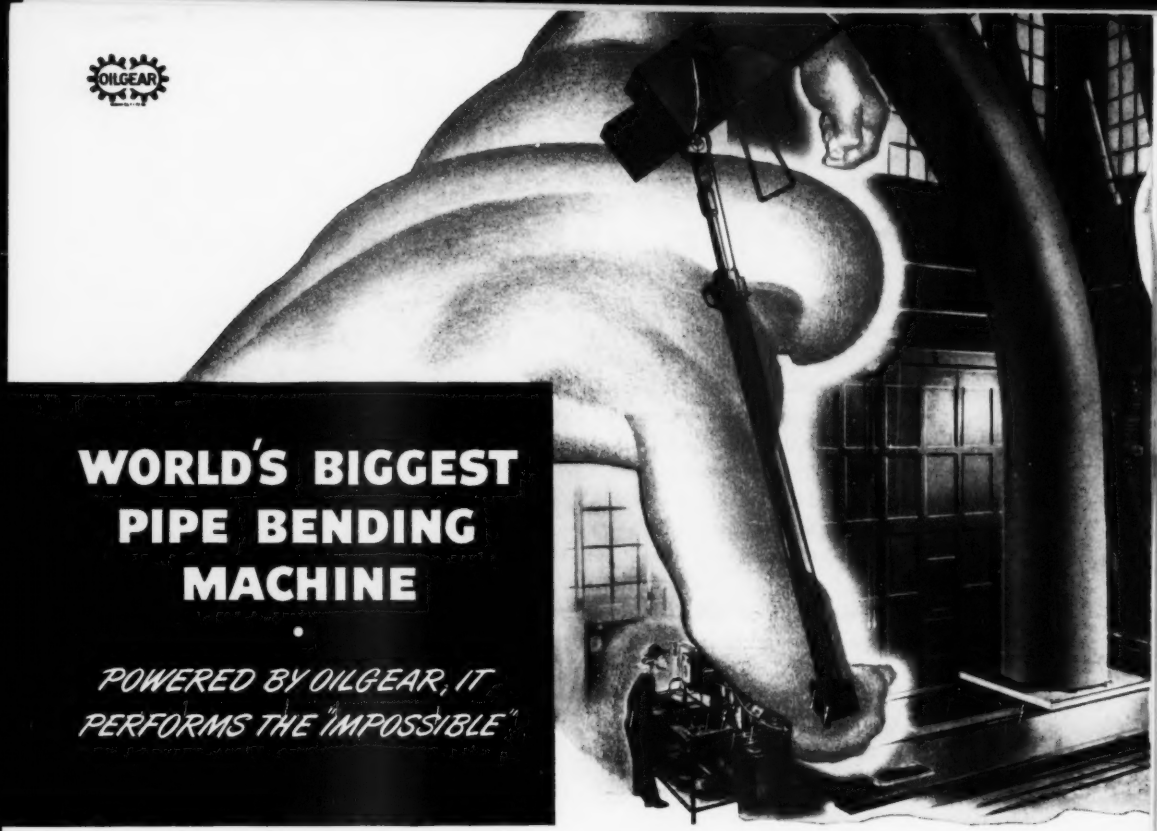

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POWERED BY OILGEAR, IT PERFORMS THE "IMPOSSIBLE"

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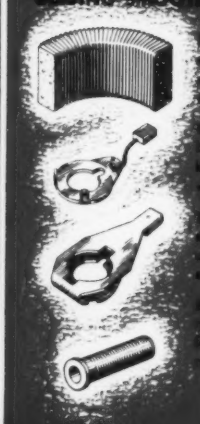

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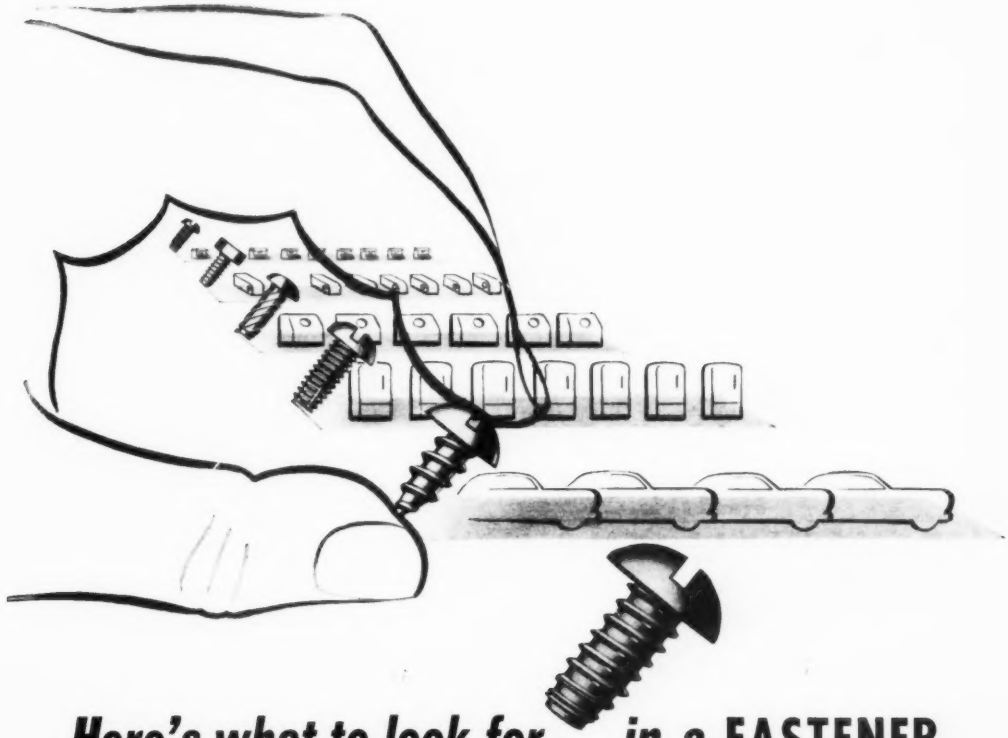

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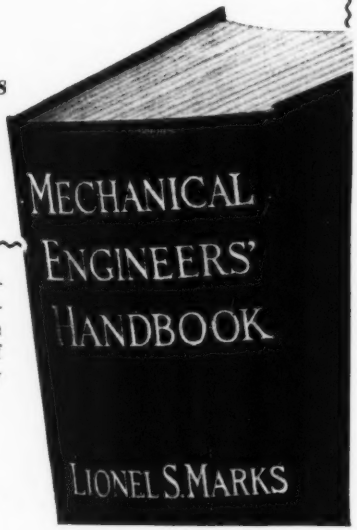

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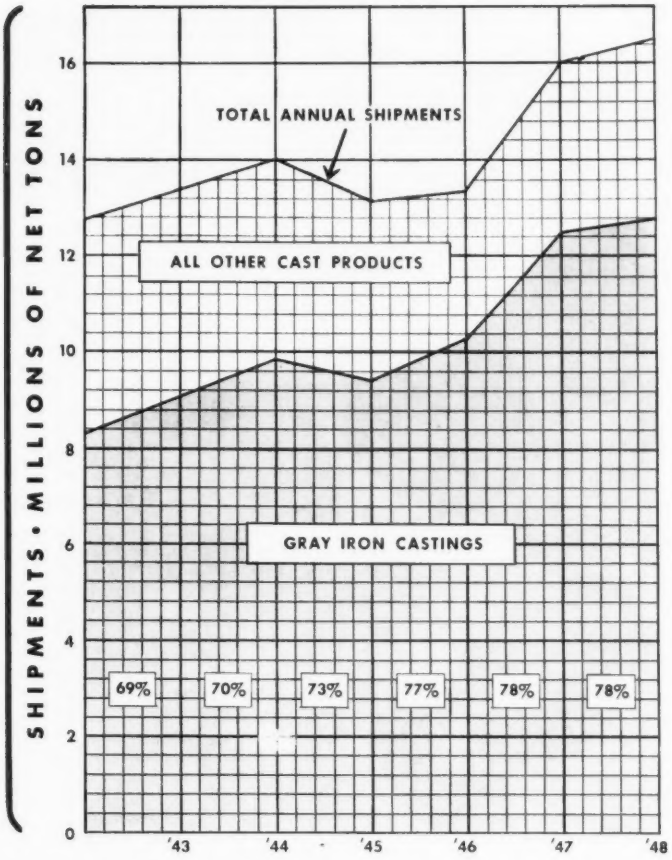

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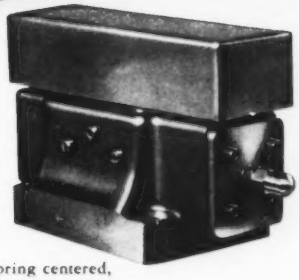
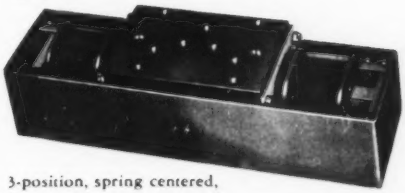
FREE DATA

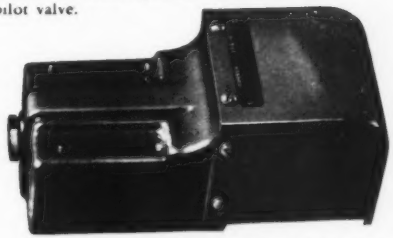
Complete engineering data sheets on the above valves are available. You'll simplify circuit design and improve product performance with these efficient valves. Write for bulletin P-46.



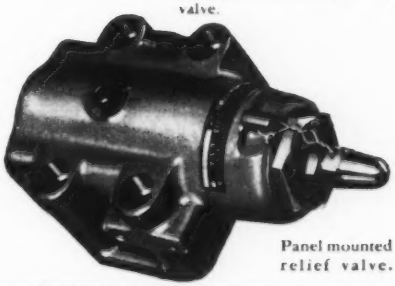
3-position, spring centered, solenoid operated 4-way valve.



3-position, spring centered, direct solenoid operated pilot valve.



2 position, solenoid operated, panel mounted 4-way valve.



Panel mounted relief valve.

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Engineering News

No. 6

Simplify design problems—Cut Costs—
Assure greater efficiency with
STACKPOLE CARBON-GRAPHITE SPECIALTIES

More and more throughout industry, the latest engineering developments are utilizing the oldest, most basic of all materials—carbon and graphite. Produced in many styles, shapes, sizes and mixes to match individual requirements, Stackpole carbon-graphite specialties offer practical, economical solutions to a wide range of mechanical, electrical and chemical problems involving such factors as friction, elevated temperatures, corrosion, arcing, shaft sealing and others. Following are but a few of the many standard and special items regularly produced:

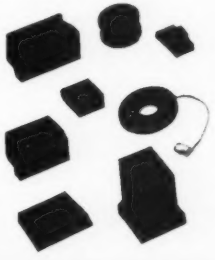
CLUTCH RINGS CHEMICAL CARBONS FRICTION SEGMENTS
CARBON PILES (Voltage regulator discs) CONTACTS
GLASS MOLDS SEAL RINGS AND WASHERS (for gas or liquid)
DASH POT PLUNGERS BEARING MATERIALS ELECTROLYTIC ANODES
RESISTANCE WELDING & BRAZING TIPS . . . *and many more*

HERE'S REAL MOLD and DIE ECONOMY FOR MANY APPLICATIONS

Carbon and graphite have interesting properties for foundry use as well as for molds and dies in such diverse fields as powdered metallurgy, glass manufacture and rail bonding. In foundry work, for instance, their high heat capacity and conductivity make carbon and graphite highly efficient as chill materials for ferrous and non-ferrous metals. In powder metallurgy, they maintain their strength under pressure at elevated temperatures much better than other materials and hence are widely used as molds for hot pressing tungsten carbide base tool materials. In still other instances, the simplicity of forming accurate carbon or graphite molds and dies lends itself to real economy. Write for suggestions based on your particular molding problem.

NON-WELDING, ARC RESISTANT ELECTRICAL CONTACTS

The non-welding, arc-resisting and non-filming characteristics of Stackpole carbon-graphite contacts make them eminently suited for many applications including use as arcing tips, distributor buttons and contactor and relay contacts. Used in combination with silver or copper, they are highly effective in circuit breakers, Diesel starting switches, relays and practically every type of contact application. Stackpole engineers welcome the opportunity to recommend standard or special contact grades for specific equipment.



WRITE FOR THIS HANDY DATA BOOKLET

Besides describing dozens of specialties, this Stackpole Booklet 40 contains a wealth of practical data on the characteristics of carbon and graphite and their engineering applications.

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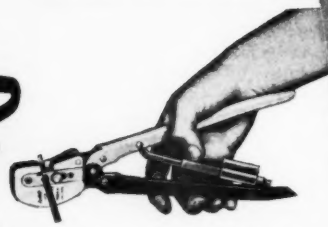

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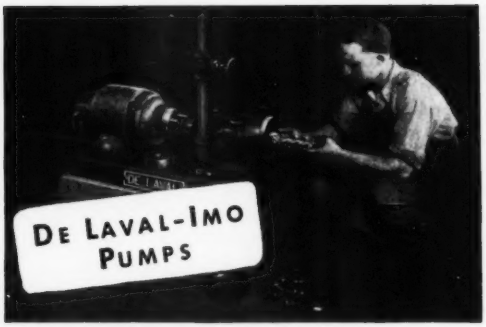

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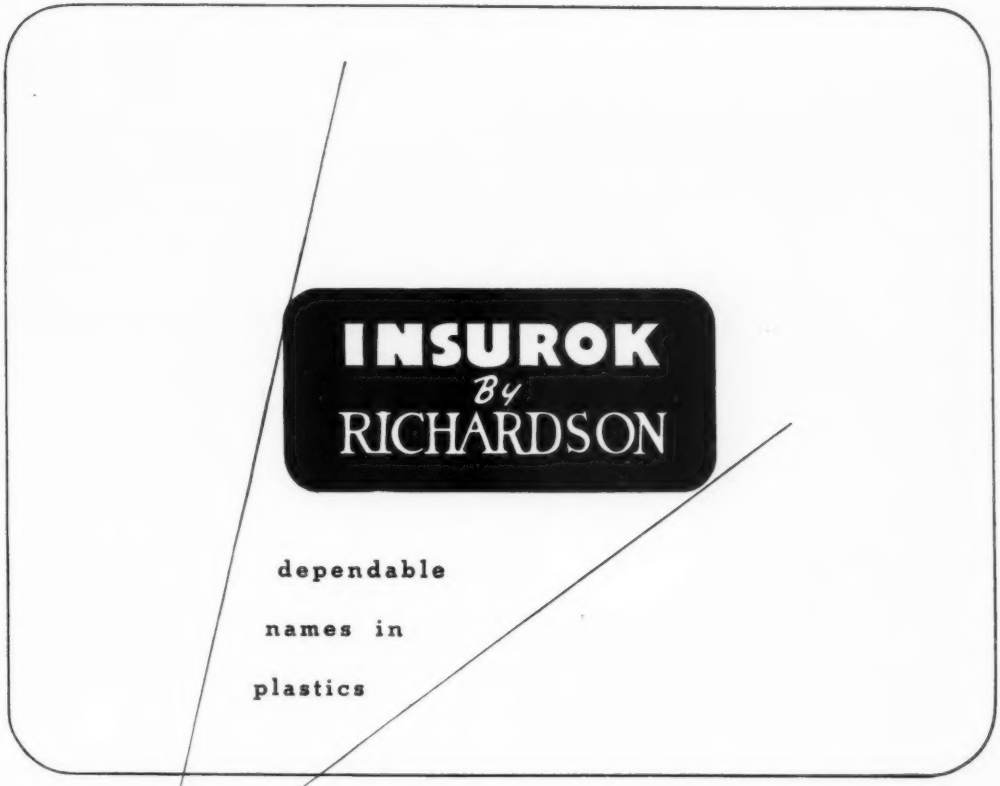

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Abbott B	1/16 — 5"	± .0002	.0002
Abbott C	1/16 — 5"	± .0005	.0005
Abbott Hardware	1/16 — 8"	± .001	.001
Abbott Industrial	1/8 — 5"	± .002	.002
Abbott Special	1/8 — 5 15/32"	± .003	.003
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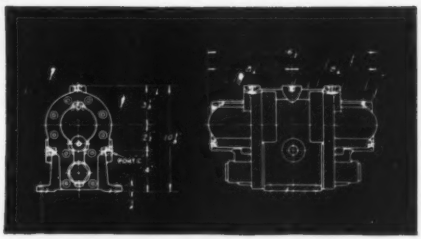

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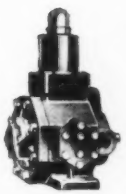

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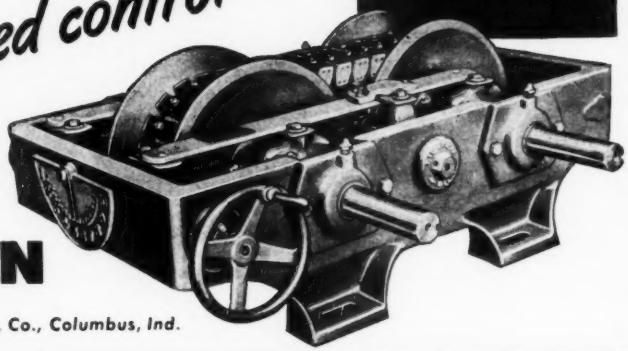

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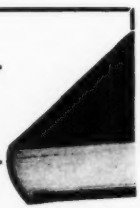

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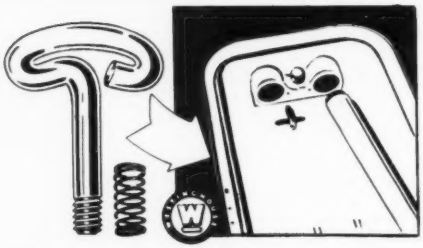

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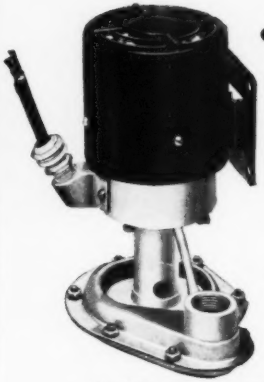

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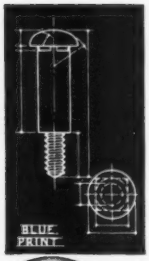

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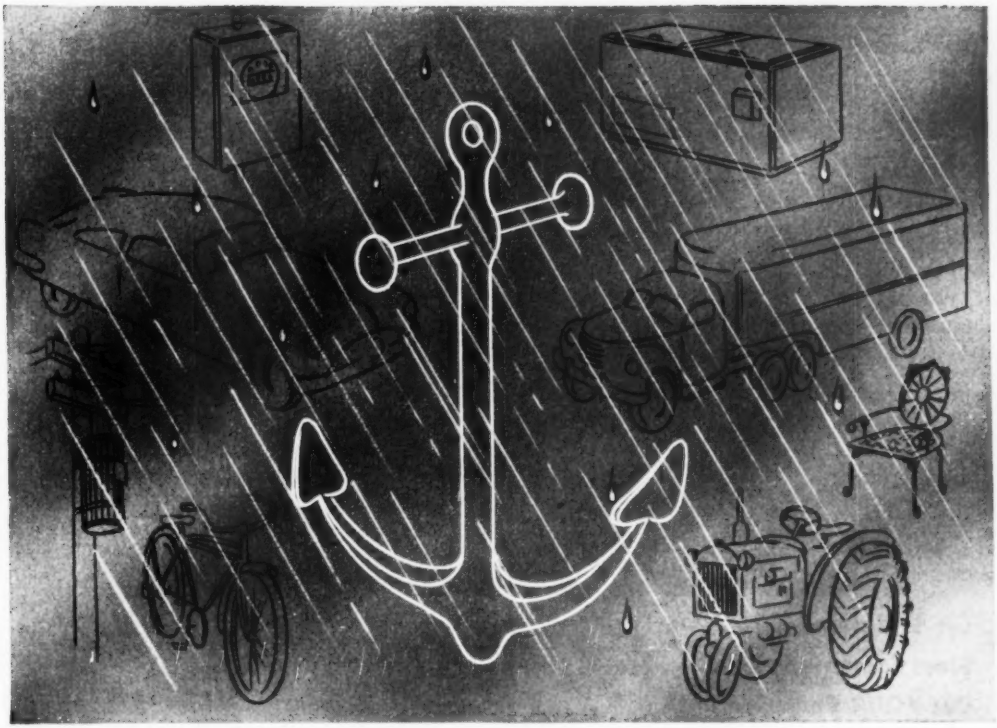

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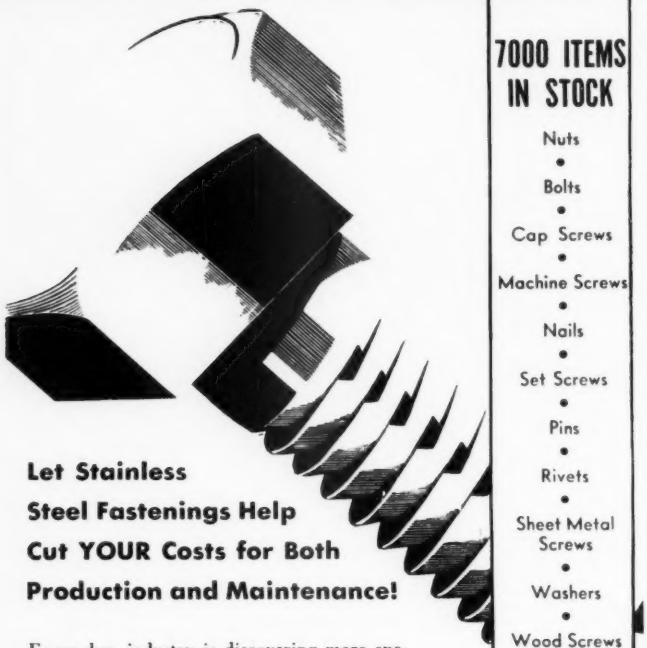

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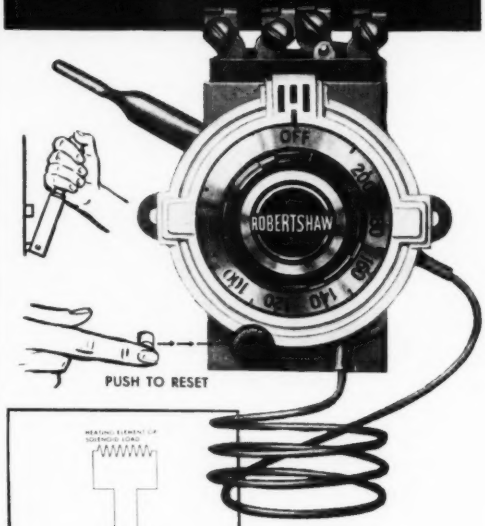

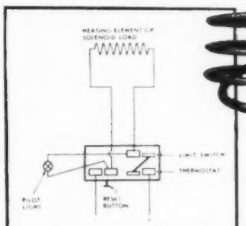

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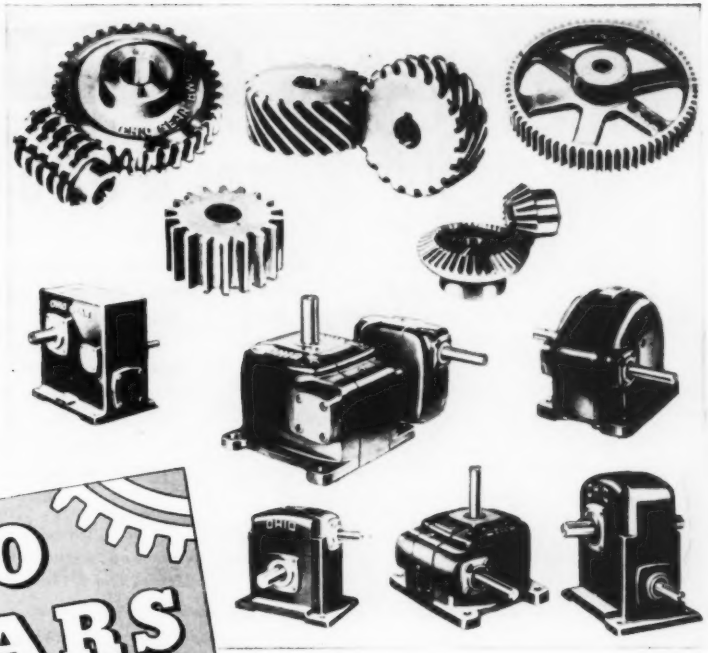

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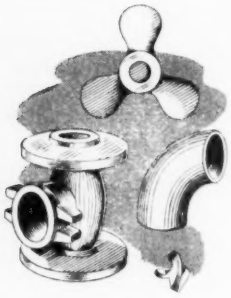

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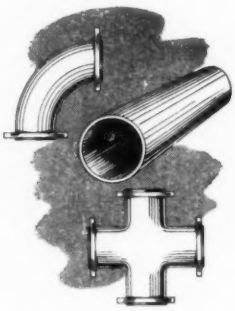

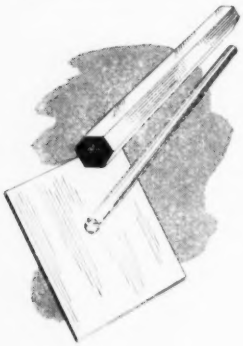

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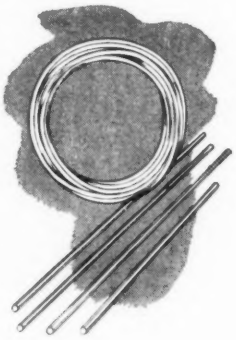

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Piasecki Helicopter Uses

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to meet space limitations and provide top performance

Built for the Navy, the Piasecki XHJP-1 seven place tandem rotor helicopter with an engine power of 525 hp recently set an unofficial world's speed record of 131 mph for this type of plane. In addition, it is the first helicopter known to have performed a loop. These are two records to be proud of as they prove the worthiness and structural fitness of the plane.

Piasecki Engineers, like many other engineers, chose *Norma-Hoffmann XLS and RXLS extra light series bearings* in the clutch and rotor transmission respectively for "suitability of size plus performance."

Having unusually large bores compared to outside diameters, Norma-Hoffmann *Extra Light Series XLS and RXLS Bearings* offer engineers and designers the advantages of compactness, light weight and ruggedness plus high anti-friction efficiency. In many cases these *extra light series bearings* provide the only solution where space is restricted.

Whether you build planes, automobiles, machine tools or other equipment, it will pay you to investigate *Norma-Hoffmann Extra Light Series Bearings.* They are available in ranges from ¼" to 22½" bore. Our Field Engineers will gladly help you with your bearing problems. Write for their assistance and catalog.

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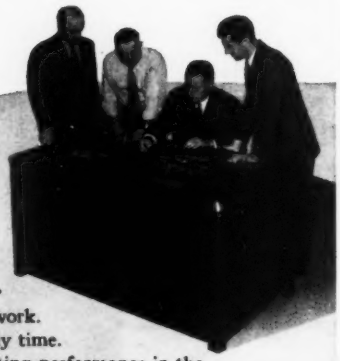
SAVED 12 COST FACTORS

IN THE VI-SPEED PNEUMATIC VISE



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To save machine work.
To reduce assembly time.
To improve operating performance in the Vi-Speed Pneumatic Vise.

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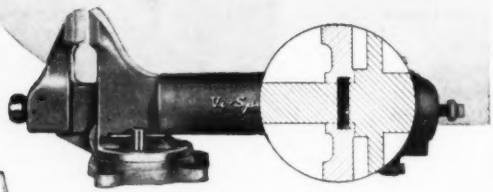
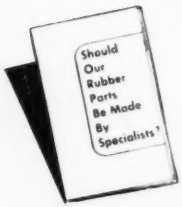
Continental Rubber Engineers developed a molded neoprene packing ring that replaces eight parts, eliminates three machine operations, and simplifies assembly—greatly reducing manufacturing costs. This rubber packing ring also eliminates subsequent "take-up" adjustments and, by reducing friction, increases the operating power and speed of the vise.





Analysis of *YOUR* product may suggest a way to save with a better engineered rubber part. The first step is to write for the Continental booklet "Should Our Rubber Parts Be Made By Specialists". It has been a "thought starter" that has helped others. *Write Today.*

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BOTH theoretical and practical, this book is definitely slanted toward engineering design and use in definite industrial applications. It brings you valuable information on: material testing, agitation, ultrasonic transducers, ultrasonic systems. It explains clearly the characteristics of ultrasonic waves that are important in practical applications: curves, waves, and complex waves; Fourier's theorem, wave trains and the law of angular transmission; the ways ultrasonic waves may be produced, and the electro-mechanical converting systems.

Evaluates Practical Uses in Many Fields

Brought out of the research laboratory and into industry, ultrasonics has tremendously broad, practical applications. This guide points the way to greater use of ultrasonics in, for example, MATERIALS TESTING: to detect flaws in metals, plastics and glass, etc.; CHEMICAL INDUSTRIES: to make better mixtures and emulsions, etc.; METALURGY: for extremely uniform mixtures free of air bubbles, etc. It likewise discusses experimental applications to systems of television, underwater signaling, depth sounding, communication, destruction of bacteria, etc.

CONTENTS

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3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
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The better the finish, the better the buy!

This is the slogan now being used to remind your customers that a good buy starts with a good finish.

And arresting advertisements like the one above, in four of the nation's top magazines* point out that a better finish means more beauty, longer life for every piece of furniture, every appliance used in the home, the school, the office.

More beauty and greater durability for everything from diaper pins to caskets.

And these advertisements mean that thirty-two million Americans (including those who buy your products) are going to take a closer look at the finish in the future.

Are you sure that you are using the best, the most durable, *most saleable* finish on *your* products? It's always wise to START YOUR BUYING WITH THE FINISH IN MIND!

*See *Time*, September 19, 1949
Country Gentleman, September, 1949
Better Homes and Gardens, September, 1949
The Saturday Evening Post, August 13, 1949

NATIONAL PAINT, VARNISH AND LACQUER ASSOCIATION, INC., WASHINGTON, D. C.

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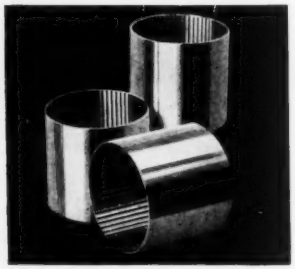
Graphited Bronze Bearings

GRAPHITED SLEEVE TYPE BEARINGS were developed primarily for applications where lubrication is difficult, likely to be neglected and where the speed of the shaft is too slow to sustain an oil film. They are also used in some applications where ordinary lubricants might damage goods or food products in process and where temperatures are too high for oil or grease.

There are three fundamental types available: cast bronze with serrated grooves, cast bronze with graphite plugs and bronze sheet metal with serrated, rectangular or diamond shape indentions.

In the cast bronze serrated type, minute, dovetailed grooves are cut into the bearing surface at a 7 degree lead. Graphite is then compressed into these serrations and remains permanently in place. This type provides from 40 to 45% graphite contact with the shaft which increases slightly with wear.

· · · Serrated type graphite bearing. Note the 7° lead and the dovetail shape of the serrations.

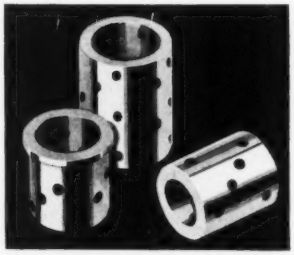


Plug type graphited bearings are produced by drilling holes of a suitable size in a cast bronze bearing on a staggered pattern through the wall. Stick graphite is then forced into these holes and remains permanently in place.

In some applications, ordinary oil grooves or combinations of oil grooves can serve as recesses to hold the graphite. It is also possible to compress graphite into grooving on the flange of cast bronze bearings when the application requires it.

The first step in producing bronze sheet metal graphited bearings is to cut serrations longitudinally into coiled strips of sheet bronze. The graphite is then forced into these serrations by a high pressure, patented process and baked under a carefully controlled temperature. The strip material is then blanked and formed into cylindrical shapes. In producing the cylindrical shape the serrations automatically become dovetailed which holds the graphite permanently in place.

Cast graphited bearings can be reamed in place, a maximum of 0.005 stock being removed. Sheet metal bearings *must* be burnished in place. The graphite used in Johnson bearings is not soluble in water, oil or gasoline. An occasional application of oil or grease where permissible will greatly increase the life of the bearing and lower the coefficient of friction. Cast graphited bearings are recommended for applications having slow speeds and minimum loads. For intermittent service or oscillating motion we recommend sheet metal with graphite. Quantity is a factor also and in large production runs of any given size, sheet metal is surprisingly low in cost.



Limiting Factors For Successful Performance

1-Speed—Load Factors:

(a) For constant running shafts—PV = 18,000# in (min.) sq. in. proj. area.

(b) For constant running shafts (with supplementary lubrication) PV = 120,000# in (min.) sq. in.

(c) For Oscillating shafts—PV = 60,000# in (min.) sq. in.

(d) Intermittent service—PV = 120,000# to 250,000# in (min.) sq. in. (use safety factor)

2-Bearing Pressures:

(a) All graphite jobs (without additional lubrication) 40 to 50# sq. in. (for speeds of 30 ft. per min.)

(b) With supplementary lubrication 350# sq. in.

3-Temperatures:

(a) Standard graphited bushings—Satisfactory up to 250° F. 275° F. (Using conventional leaded bronzes and serrated type.)

(b) For temperatures up to 400° F. Conventional leaded bronzes with graphite plugs.

(c) For temperatures—Up to 1000° F. Special lead bronze alloys with graphite plugs. At higher loads, oil should be used in conjunction with the graphite plugs for higher efficiency.

4-Running Clearances:

(a) Constant running shafts—50% higher than standard.

(b) Oscillating shaft—Standard allowance can be used.

5-Wall Thickness:

Minimum thick. $\frac{1}{16}$" for O.D. up to 1".
Minimum thick. $\frac{3}{16}$" for O.D. over 1". Serrated type

Max. wall thick.—Optional to designer. For plug type graphite—wall to be same as diameter of graphite plug—½ min.

6- Graphited bushings should be recommended for speeds less than 30 ft. per min. for at such low speeds it is impossible to develop film pressure necessary to prevent metallic contact.

7-Stock Allowance for finishing

(a) It is necessary to finish bushing in assembly. Reaming stock allowance of not more than 0.005 should be allowed for cast bronze graphited.

(b) At least 0.004 stock for burnishing sheet metal graphited.

Ledaloyl Bearings

While graphited bearings are sometimes referred to as "Self-Lubricating" Johnson Bronze produces another type by powder metallurgy known as *Ledaloyl*. This bearing is low in cost, high in efficiency and holds up to 35% oil by volume. It is particularly economical when produced as a self-aligning, flanged or other odd shaped part as there is no machining required. Write for complete details.

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

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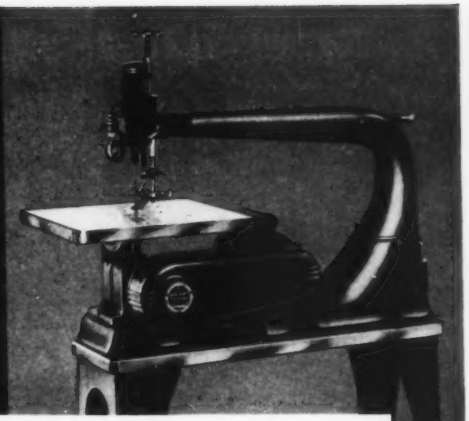


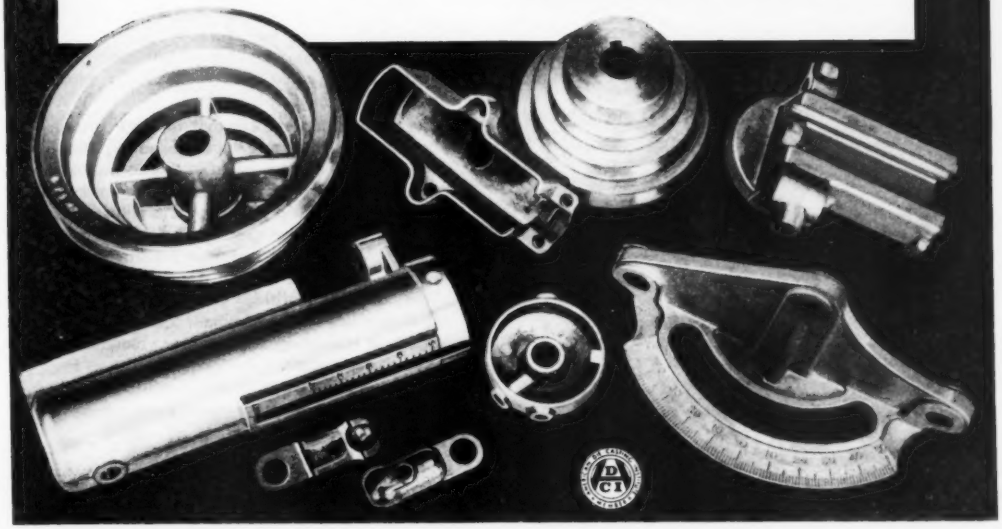
Rapid production—that's die casting's "middle name"; because any product, simple or complex, can be produced almost instantly by die casting . . . and time-consuming machining operations are reduced to a minimum or eliminated, entirely.

Look at these components of the new Walker-Turner 24-inch, 4-speed jig saw: intricate shapes—with bosses, holes, runners, guides; pulley sheaves for variable speed drives; parts bearing graduated scales. All are produced rapidly by Mount Vernon—so accurately, they require little or no machining; so clean, they can be adapted to any type of finish.

Yes, die casting means cost-cutting all along the line—savings in time, effort and material that team to slice unit costs.

Have you weighed your present manufacturing procedure against the many advantages of die casting? If not, consult with us. We feel confident we can show you the way to new production economies and product improvements—profitable operation in today's highly competitive market.

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK



EVERYWHERE in

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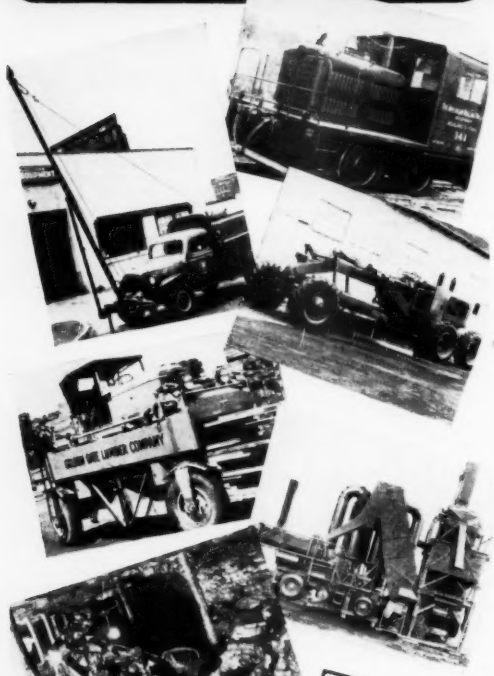


AND MANY OTHERS

These are just a few of the many famous manufacturers throughout industry using Blood Brothers Universal Joints. No matter what your problems in flexible power transmission, Blood Brothers have the experience and the production facilities to help you. Write for complete engineering data.

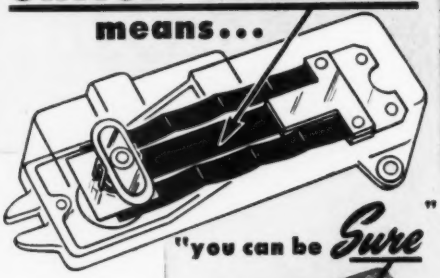
UNIVERSAL JOINTS FOR INDUSTRY

BLOOD BROTHERS MACHINE CO.

Allegan, Michigan Chicago Office: 122 S. Michigan Ave.

Divison of Standard Steel Spring Co.

CHACE BIMETAL means...



"you can be Sure"

with the Westinghouse CLOSTEMP THERMOSTAT

No. 32—Product of Westinghouse Electric Corporation Meadville, Pa.

Chace Thermostatic Bimetal maintains the "hairline" control that has sold more than 3,000,000 Westinghouse thermostats. Typical of these is the Clostemp water heater thermostat shown above. The dependable response of Chace Bimetal assures precision control, while positive snap action is obtained through a pre-stressed shape pressed into the bimetal element.

Requirements for the thermal element in the Clostemp include high torque and deflection rates in a temperature range between 120°F. and 170°F., making Chace No. 2400 the ideal bimetal for this application.

The ideal actuating element for *your* product in the fields of temperature response, control or indication can be found in one of the many bimetals comprising the Chace line. All are available in strip form or finished pieces fabricated to your specifications. Build maximum salability and customer satisfaction into *your* product . . . specify dependable Chace Thermostatic Bimetal for the actuating element. Our engineering department will be glad to assist in selecting the proper bimetal for your requirements.

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Manufacturers of Thermostatic Bimetals

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ANOTHER 3M COMPANY SERVICE STORY

Interior coating licks gas tank corrosion

1 POURING measured dose of free-flowing vinyl-based "Coro-Gard" No. 11 into welded gas tank for Schramm Compressor. Purpose, to give interior a coating impervious to gasoline or water, prevent rust.

2 ROCKING the closed tank sloshes coating into every nook and cranny. After 24-hour draining and drying welded seams and fittings are covered with thin, even film, adhering perfectly to entire inside surface.

3 TANKS READY for painting. John A. Moore of Schramm's Method Dept. checks tank. "Coro-Gard" is tops wherever metal must have a long, rust-free life unaffected by salt or fresh water, many acids, alkalies and solvents.

4 FINISHED COMPRESSOR UNIT is ready for delivery. Gas tank will now withstand corrosion caused by water, other fuel impurities. And gasoline cannot embrittle coating. Send us details on your adhesive or coating problem. Production-engineering help free.

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3M BRAND ® ADHESIVES

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Fastening Operations Cost Less with an

Composition board and impregnated fibreboard being fastened together with the Acme-Morrison Metal Stitcher.

ACME-MORRISON METAL STITCHER

and are done faster . . . stronger . . . neater

If you fasten sheet metal to metal or any non-metallic material, here's why you should do the job with an Acme-Morrison Metal Stitcher:

1. ***To save time.*** **In one operation, forms its own stitch or staple from a continuous coil, drives it through the material, and clinches it at the rate of 280 per minute.**
2. ***To save material.*** **Replaces rivets, screws, nails, bolts and spot welding with inexpensive wire stitches.**
3. ***To save money . . .*** **by increasing production, eliminating costly, unnecessary operations. No pre-punching, pre-drilling, matching or inspection required.**

For example: A furnace manufacturer cut an assembly cost from 17½c to 3½c per unit by replacing rivets with wire stitches. A maker of insecticide spray guns reduced his labor costs 38%, and cut material costs 91%, by replacing two screws with wire stitches.

Find out how similar savings can be applied to your assembly line. Mail the coupon today.

CROSS-SECTION VIEWS OF STITCHES

STITCHING WIRE DIVISION

ACME STEEL COMPANY

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about

PRODUCT ENGINEERING'S

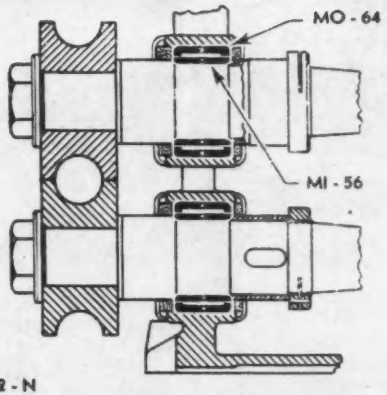
advertising pages . . .

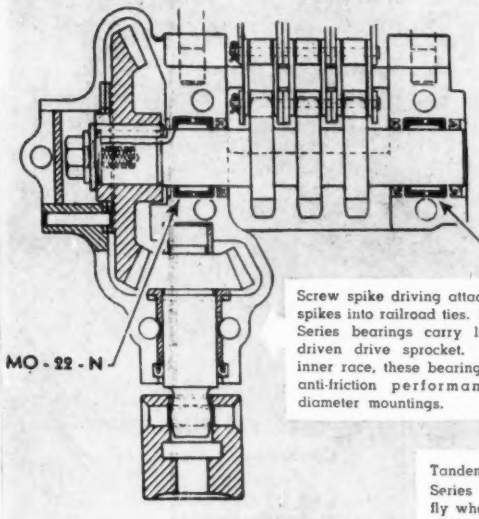
In 1948, PRODUCT ENGINEERING again ranked among the first four of all industrial monthly magazines in advertising volume. Over 500 manufacturers used 3,286 advertising pages to tell you about their parts, materials, sub-assemblies or finishes . . . and how they can help you in designing better products to sell at lower prices.

This advertising is important to you . . . it brings you the latest available information on a host of product components that can help you to do a better job. And all during 1949 this advertising will continue . . . at a time when the return of the "buyer's market" lays particular stress on designing better products to sell at lower prices . . . to bring you the facts on how to do it, and what to do it with.

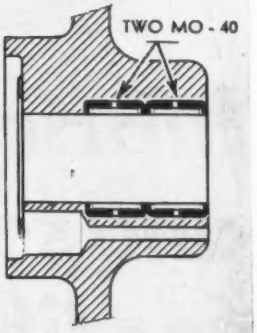
PRODUCT ENGINEERING

In this continuous tube welding machine, MULTIROL SE Series bearings carry the tube forming load as journal bearings. To support the heavy load, shafts are kept large, but journal dimensions are held to the minimum — reduces cost.

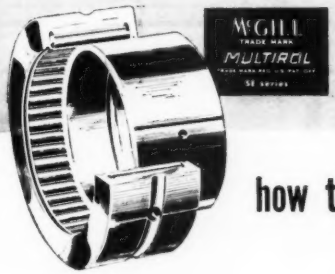




Screw spike driving attachment screws spikes into railroad ties. MULTIROL SE Series bearings carry load of chain driven drive sprocket. Used without inner race, these bearings provide full anti-friction performance in small diameter mountings.



Tandem mounting of MULTIROL SE Series bearings on a punch press fly wheel. Bearings are mounted in pairs for even distribution of extra heavy load and easily carry impact of shock load every time clutch is engaged. Shaft serves as inner race permitting more compact mounting.



how to anti-frictionize for improved performance

THE MULTIROL WAY

The efficiency of any machine can be raised when plain friction bushings are replaced with MULTIROL SE Series full type roller bearings. Speeds are easily increased and accuracy improved over a longer expected bearing life.

The MULTIROL Way requires less maintenance because lubrication can be provided through either the shaft or housing — oil holes and channels in both outer and inner — no need for constant oiling — no danger of dry journals when lubrication is temporarily neglected.

Costs less too. Ordinarily large housings can be reduced to accommodate the MULTIROL Bearing minimum OD for a given shaft size and load capacity. Remember also that eliminating friction saves on power imput.

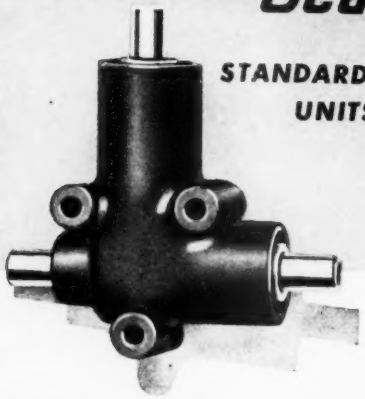
MULTIROL SE Series bearings are anti-frictionizing machines in all industries. The above drawings illustrate typical examples of improved bearing applications. We will gladly make engineering recommendations for you. Write today for helpful MULTIROL Bearing literature.

Address McGill Manufacturing Co., Inc., 201 N. Lafayette Street, Valparaiso, Indiana, for your copy of MULTIROL Bulletin SE-48.

McGILL
TRADE MARK
precision bearings

ANGLE Gear

STANDARDIZED UNITS



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ANGLE Gear units are furnished in all four models lubricated and sealed for life to eliminate the maintenance problem. The use of hardened alloy steel bevel gears and precision ball-bearings guarantee long trouble-free service.

ANGLE Gear units may be used for either manual operation or for power transmission. Present models are typically rated to transmit ⅓ H.P. at 1800 R.P.M. for 2500 hours continuous duty. *All models now rated 500 inch pounds ultimate static torque.*

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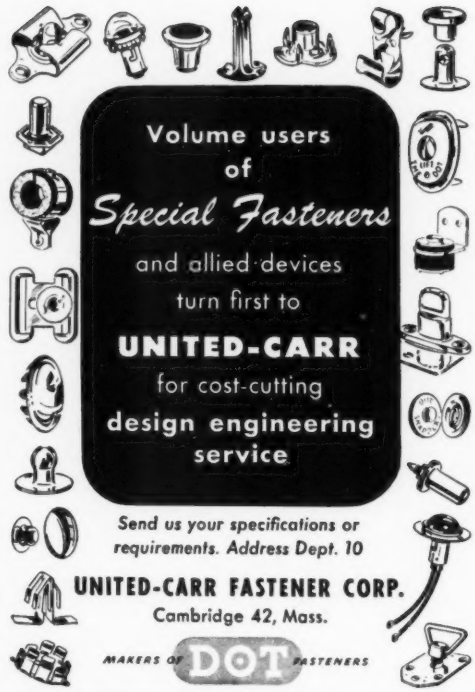

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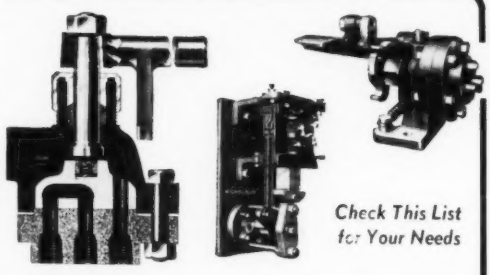

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		Ore Tables
		Automobile Lifts
		Special Applications

Nicholson standard and special valves in lever, foot, solenoid, motor types; for air, gas, oil, steam, water; size ¼" to 2½"; press. to 5,000 lbs. CATALOG 546

W. H. NICHOLSON & CO. 200 OREGON ST. WILKES-BARRE, PA.

Traps • Control Valves • Steam Specialties

WARD TELEVISION ANTENNAS MADE
STRONGER, LONGER-LASTING,
EASIER TO INSTALL with
J&L STEEL PERMA-TUBE
J&L STEEL
The vertical mast and cross-arms of the Ward "Minute Man" antenna are made of J&L PERMA-TUBE. It takes just 60 seconds to remove the preassembled antenna from its box and swing all arms into position as shown here. PERMA-TUBE antennas combine strength, rigidity and rust-resistance—give longer *trouble-free* service—and better television reception.

PERMA-TUBE may be used for many applications where strength, rigidity, rust-resistance, and attractive appearance are necessary.

By using the new exclusive rust-resisting J&L PERMA-TUBE for the vertical mast and cross-arms in the "Minute-Man" series of television antennas, Ward Products Corporation, Division of the Gabriel Company, Cleveland, Ohio, builds-in the following advantages:

1. **Greater structural rigidity with smooth, attractive appearance. Greater strength to resist ice loads.**
2. **Clearer, steadier, television reception. Less vibration from wind.**
3. **No mechanical seam in Perma-tube to invite rust which would reduce the torsional strength.**
4. **Ease and speed of installation . . . at less cost.**

J&L PERMA-TUBE is a light-wall, electricweld steel tubing, coated inside and out with an exclusive plastic-type, weather-resistant finish. PERMA-TUBE can be furnished: bent . . . expanded . . . flanged . . . swaged or fluted.

J&L PERMA-TUBE for television antennas, *costs less than any other tubing with comparable strength, rigidity and rust-resistance.*

J&L PERMA-TUBE is not only applicable to television antennas, but also wherever strength, rigidity and rust-resistance are important. It is available in all regular sizes and shapes of J&L Electricweld Tubing and in lengths up to 10 feet. Return the coupon TODAY for complete information on this new J&L product.

Jones & Laughlin Steel Corporation
409 Jones & Laughlin Building
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Please send me complete information on the new J&L STEEL PERMA-TUBE mechanical tubing.

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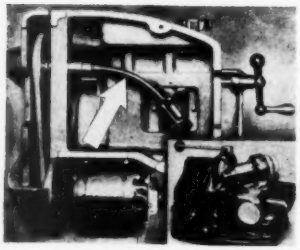
From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY (*hi-tensile steels*).

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

S.S. White

FLEXIBLE SHAFTS SIMPLIFY DESIGN

This Flexible Shaft Drive Permits Adjustment of Driven Part



In this valve grinding machine, it was desired to make provision for three-way adjustment of the power driven chuck. This was easily accomplished with a single basic mechanical element by using an S.S.White flexible shaft, as shown.

Photo courtesy of Van Norman Machine Co., Springfield, Mass.

FOR driving or controlling parts which require adjustment in operation, there's nothing like S.S.White flexible shafts. They are smooth operating, dependable and adaptable to a wide range of design and operating conditions. They come in a large selection of sizes and characteristics, made up to your specific length requirements and ready for easy coupling to driven or controlled parts.

FREE—FLEXIBLE SHAFT HANDBOOK

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260 pages of facts and data on flexible shaft application and selection will be sent on request if you write for it on your business letterhead and mention your position.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO. — DEPT. D — 10 EAST 40th ST., NEW YORK 16, N. Y.

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Chances are you will always find in PRODUCT ENGINEERING's "New catalogs and Bulletins" insert several listings offering literature which will supplement the articles and advertisements which are of greatest interest to you.

So, each month, be sure to check through the "New Catalogs and Bulletins" and send us your requests. Without cost to you, we'll see to it that the manufacturers concerned receive your requests promptly.

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PRODUCT ENGINEERING
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Fafnir announces...

Spherical Roller Bearing

Pillow Blocks

As a further service to its customers, The Fafnir Bearing Company is adding a line of Spherical Roller Bearing Pillow Blocks to amplify its range of power transmission units. The Fafnir line will then provide for every conceivable pillow block requirement—speed, load and operating condition—in light, standard and heavy duty series—ball or roller bearing type.

The Spherical Roller Bearings for these units will be manufactured by The Torrington Company, well-known name in this specialized anti-friction bearing field. Fafnir Spherical Roller Bearing Pillow Blocks will be available *only* as complete units: Torrington spherical roller bearings will be sold only by The Torrington Company.

Fafnir Spherical Roller Bearing Pillow Blocks will be distributed in the same manner as Fafnir Ball Bearing Pillow Blocks. First shipments will be made about January 1, 1950. Literature listing the complete range of sizes and types will be available at a later date; meanwhile, your inquiry, with specifications and blueprints, is cordially invited.

The Fafnir Bearing Company
New Britain, Connecticut

Unique Fenwal Thermoswitch* Thermostat Amazes Heating Experts by Performing the "Impossible!"

YES, manufacturers are discovering the remarkable line of Fenwal THERMOSWITCH* units can give them help they thought mechanically impossible! A coal furnace manufacturer, for instance, found the Fenwal THERMOSWITCH* the *only* thermostat able to solve the problem of automatic grate shaking. Ordinary thermostats either could not stand up under punishment . . . or were too slow in operation.

You, too, can benefit from this unbeatable THERMOSWITCH* performance. It has countless applications, does away with costly control equipment, opens up new forms of precision-control in all types of manufacturing processes. Low upkeep cost, too. The THERMOSWITCH* is accurate, rugged and simply constructed, with mechanism fully enclosed by the temperature-sensitive shell. Investigate it now!

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15 Pleasant St., Ashland, Mass.
Temperature Control Engineers

Fenwal

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*Reg. U. S. Pat. Off.

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In this bulletin—*yours for the asking*—there's a compactly-told story on two modern surface hardening methods—*Chapmanizing* and *Malcomizing*. Both are important to anyone interested in longer-wearing parts.

CHAPMANIZING produces an alloy-like case (from .002" to .035" in depth) on low carbon steels in only 1 to 4 hours. It's a tough, ductile case that will not chip or check. And it's ready for use with minimum finish grinding, for the surface comes out silver-clean.

Metallurgical Sales Division of
THE CHAPMAN VALVE MFG. CO.
INDIAN ORCHARD, MASS.

MALCOMIZING gives stainless steels a case that ranges in depth from .005" to .015". Hardness approximates 1000 Vickers Brinell. Finish grinding or lapping is possible, for maximum hardness is slightly below the surface.

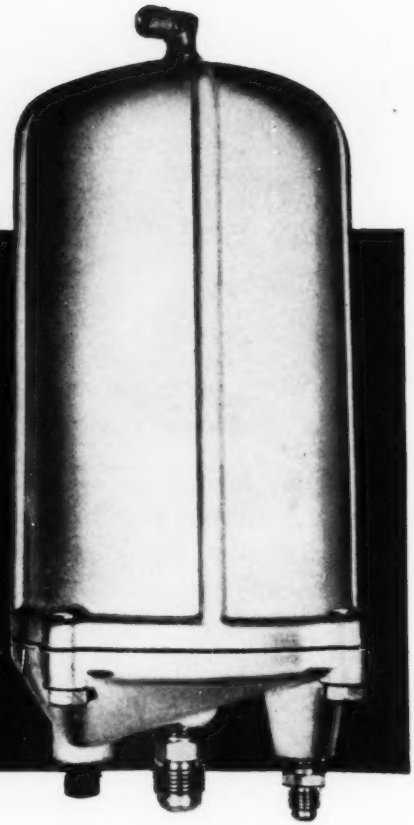
If you would like the full story on these two widely used hardening processes, just fill in and mail the coupon.

Metallurgical Sales Division of
The Chapman Valve Manufacturing Co.
Indian Orchard, Massachusetts

Please send me your booklet on CHAPMAN PROCESSES and the name of the nearest commercial heat treater who can *Chapmanize* ☐ *Malcomize* ☐ for me.

Name .....
Company .....
Street .....
City ..... *State* .....

Two high strength zinc base die castings form the housing and the bolted-on cover for this sump manufactured by Martin & Schwartz, Inc., Salisbury, Maryland.



ENGINEERS CHOOSE

Zinc Base Die Castings

FOR RUGGED SERVICE...

THERE were good reasons why Martin & Schwartz, Inc., of Salisbury, Md., used zinc base die castings to house the air separation float chamber in their gasoline vending pumps.

These two castings are required to meet the rigid specifications of Underwriters' Laboratories, Inc. for zinc die castings used in the fluid system of gasoline service station pumps. Castings are subjected to tensile and accelerated aging tests, and are further tested at assembly to withstand an internal hydrostatic pressure of 120 pounds p.s.i.

Here's an object lesson for manufacturers in many lines: Overall savings in production, assembly and finishing . . . extreme accuracy and dimensional stability . . . good looks . . . strength . . . corrosion resistance are yours when you specify zinc base die castings for your products.

*Reg. U. S. Pat. Off.

Anaconda does not make die castings, but supplies Anaconda Electric* Zinc, 99.99+% pure, to the die casting industry.

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Subsidiary of Anaconda Copper Mining Co.

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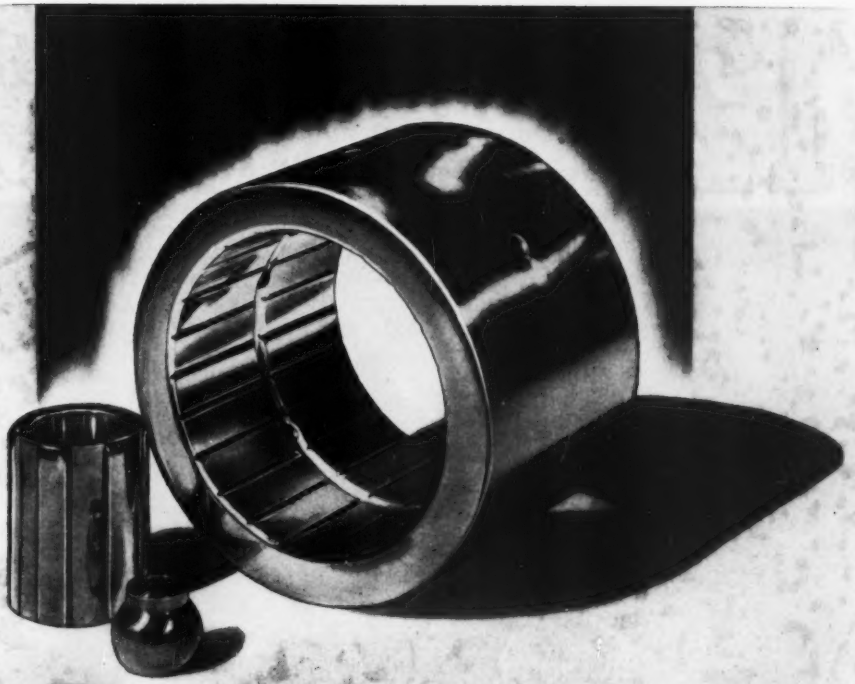

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When you buy Bunting Bronze Bearings you receive more than just a physical bronze bearing. More than forty years of experience, the technical skill of thorough metallurgists and engineers, the output of equipment designed for closest tolerance and finest finish—these and more are an invisible part of each Bunting Bronze Bearing and Bar.

A sales organization of graduate engineers is able to intelligently discuss your design and production problems with you. A manufacturing organization that moves swiftly responds to your production schedule on time.

When you buy Bunting Bronze, the entire Bunting organization is alert to the fact that you are a customer and that you want service as well as a product. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in principal cities. 90

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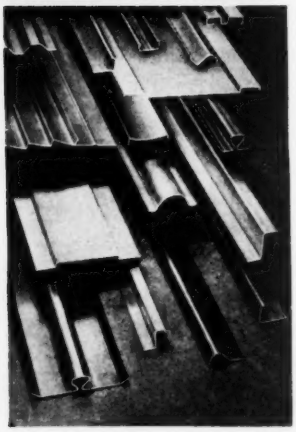
BRONZE BEARINGS · BUSHINGS · PRECISION BRONZE BARS

12 examples of Cost Cutting

made possible by combining different operations in a Yoder roll-forming production line

No. 3 Seam-welding, coiling and cutting into rings, combined with cold-roll-forming



Coiled strip from the coil box (extreme right) is here seen being pulled into the cold roll forming machine whence it emerges as a twin tubular section. Continuing on its way, it next passes through two seam welders. An extra roll stand on the second seam welder, helps pull the section through the welders and push it into and through the Yoder coiling and automatic Cut-Off machine. These four operations are performed in a single pass through the continuous production line, with only one operator and a helper — the same as would be required for roll forming alone. This Yoder line makes 6,000 bicycle rims per day. It was installed for the Arnold Schwinn Co., Chicago, world-famed bicycle manufacturers.

A variety of other shapes may be similarly formed, seam or spot welded, curved or coiled; several materials can be combined into one composite shape; felt, rubber, adhesives and other materials can be inserted or injected; tubular shapes with open or lock-seams may be made, and a multiplicity of other operations performed, at little or no extra cost. Thus drastic production economies may be effected.

Yoder engineers will be glad to design for you the kind of roll forming and auxiliary equipment best suited to your needs, simple or complex. Consultations, estimates, recommendations for the asking.

THE YODER COMPANY
5524 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

ROLL FORMING, TUBE MILL AND SLITTING MACHINERY

41 YEARS' LEADERSHIP • COILING • SLITTING • FORMING • EMBOSSING • CURVING • WELDING • CUTTING-OFF

Standardize on Dependability

AUTOMATIC ELECTRIC

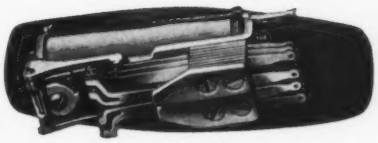
CHICAGO

RELAYS

In Automatic Electric's complete line of relays, there are over forty basic types—offering spring and coil combinations in almost infinite number. They are dependable and proved products of an organization that has made electrical remote control its business for more than fifty years.

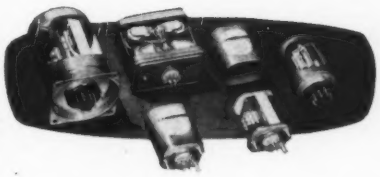
New Class "B" Relays

The newest and most outstanding member of Automatic Electric's relay family is the Class "B"—even better than the widely used, *widely copied* Class "A" Relay. Designed for ordinary relay service—opening, closing or switching circuits—and for extremely high-speed operation. Independently operating twin contacts assure perfect contact operation. Contact points are dome-shaped to maintain uniformly low contact resistance. May be arranged in one or two pileups with maximum of 16 contacts on 13 springs in each pile.



Hermetic Sealing Available To Maintain Automatic Electric Quality

All Automatic Electric Relays can be obtained in hermetically sealed housings to maintain the high quality for which these relays are famed. The "sealed-in" controlled atmosphere protects them from electrical or mechanical failure resulting from varying conditions of temperature, dust, humidity, acid, fungus or air pressure —and makes them completely tamperproof.



SWITCHES

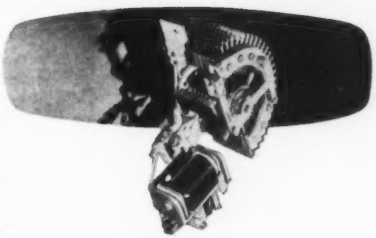
Automatic Electric Stepping Switches are designed and built to assure exceptionally long life. A complete range of Automatic Electric Switches is available for all remote control applications.

The New Type 45 Switch

Here, for example, is a rotary switch that's new and better! *Faster* . . . 70 steps a second. *Greater capacity* . . . up to 10 (or more) 25-point bank levels, with single-ended wipers available for 50-point operation. *Simpler* . . . only one field adjustment.

Compact rotary and re-set type switches are also available with 10-point bank levels and speeds of 35 steps a second for automatic or remote-control operations.

And there's the famous "Two-Motion Switch" that selects one circuit from among two hundred in just *2 seconds* or less. It's a re-set type switch adaptable to either automatic or remote control.



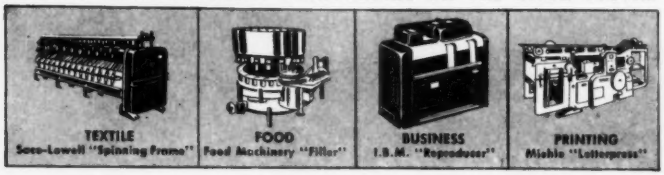
For help in the field of remote control, call in an Automatic Electric field engineer. Meanwhile, send for helpful literature. Address AUTOMATIC ELECTRIC SALES CORPORATION, Chicago 7, Ill. In Canada: Automatic Electric (Canada) Ltd., Toronto.

RELAYS SWITCHES

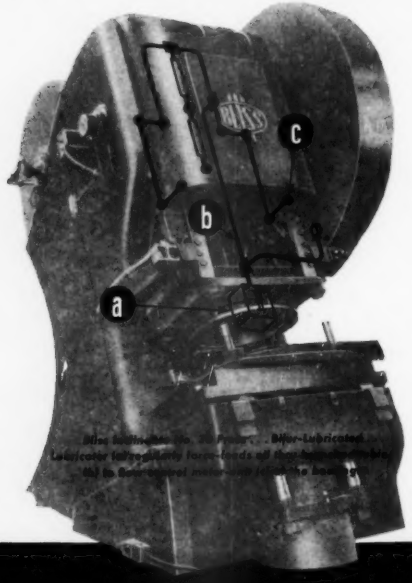
AUTOMATIC ELECTRIC

CHICAGO

LEADING MANUFACTURERS STANDARDIZE ON THE BIJUR SYSTEM



reduce bearing wear



by controlling oil film at the bearings

Oil film at the bearings keeps the metallic surfaces apart, reducing wear to a minimum. This oil film must be maintained *constantly* to be effective.

Lubrication by hit and miss methods can't be depended upon to keep bearings running smoothly. Proper lubrication requires a system which force-feeds the correct amount of oil to all bearings and carefully controls the oil flow at each individual bearing *automatically*.

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Photos courtesy Connecticut Railway & Lighting Lines.

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There is a type and size for carrying fluids, steam, semi-solids, or gases. If yours is a special problem, American engineers offer you their long years of varied experience in connector applications.

For complete information on American Flexible Metal Hose and Tubing, write for literature. Address your inquiry to The American Brass Company, American Metal Hose Branch, Waterbury 88, Connecticut. In Canada, The Canadian Fairbanks-Morse Co., Ltd.

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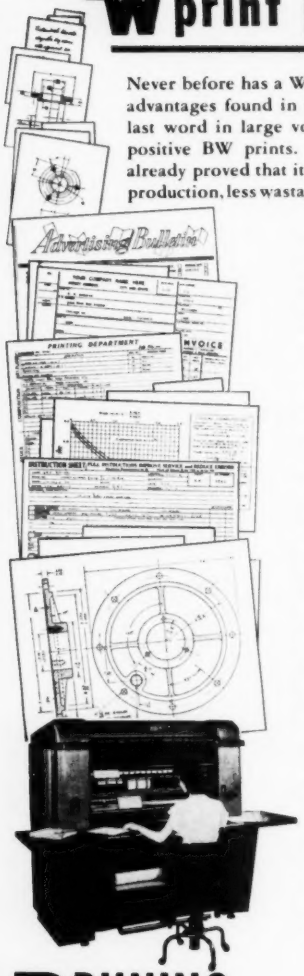
ANACONDA from mine to consumer American

flexible metal hose and tubing

large volume BW print production



Never before has a Whiteprinter been able to offer you all the advantages found in this new Volumatic Model 93. It is the last word in large volume production of high quality direct positive BW prints. Advance models of this machine have already proved that it reduces reproduction costs . . . by faster production, less wastage, lower maintenance, simpler operation.

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Faster operation. The new Volumatic produces BW Prints at speeds up to 105 square feet a minute. The prints are delivered dry and ready for instant use.

Completely odorless. The BW Process is completely odorless. BW machines do not require outside ventilation or exhaust ducts. They can be installed *anywhere* without offense.

It is mobile. There are no pipe or plumbing connections to tie this machine to one spot. It can be moved to convenient locations.

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***Send today* for full information.** Let us send you a complete file of literature describing the new BW Model 93 and the BW mediums you can use with it. See for yourself the extreme versatility, economy and speed of this machine. There is no obligation.

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DON'T think of Allegheny Ludlum as a steel producer in the ordinary sense. We don't make "ordinary" steels.

Our job is to create and develop materials in the special alloy field: stainless and heat-resistant steels, tool and die steels, carbide metals, special electrical and magnetic materials, and super-alloy steels for high temperature service. The function of these products is either to do existing jobs better than ordinary steels or other materials can do them; or to reach out into new fields and do jobs that previously couldn't be done at all. In practically every case, the use of these special alloy steels proves not only to be economically sound, but actually cheapest in the long run.

Do you want to *add* something to present products: longer life, more wear, better looks, greater strength, less weight, finer performance? *Let us help you do it.* Do you have a new device, or re-design, still in the "good idea, but haven't found the right material" stage? *Call us in—that's our job!*

Complete technical and fabricating data—engineering help, too—yours for the asking. W&O 2380

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One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your business.*

Why you and your advertising manager are partners

FROM WHERE YOU SIT, advertising may look like the "glamour department" of your company—necessary, of course, but pretty far removed from the hard-headed realities of the production line.

But take a closer look. In one respect, the advertising manager's job bears a striking resemblance to your own.

You're production-minded. You're concerned with anything that will improve plant procedures, speed up assembly time, prevent waste, and reduce the manufacturing cost per unit.

And that is precisely where you walk arm-in-arm with your advertising manager. Because he thinks the same way about the *manufacture of a sale.*

The whole process of selling and distribution are his assembly line. And every time he can reduce the unit cost of a sale by so much as a few cents, he increases your company's chance to show a profit.

Ask him for a definition of advertising, and he will probably tell you that it is simply *mechanized selling,* a machine that multiplies the productive capacity of the sales force — seeking out prospects, arousing their interest, creating a preference for the things your company makes.

And when it is concentrated among the hand-picked readers of business papers, advertising becomes the most efficient machine this partner of yours has found for lowering the cost of producing a sale.

What are the ten ways to measure the results of your business paper advertising? You'll find the answers in a recent ABP folder, which we'll be glad to send you on request. Also, if you'd like reprints of this advertisement (or the entire series) to show to others in your organization, you may have them for the asking.

PRODUCT ENGINEERING

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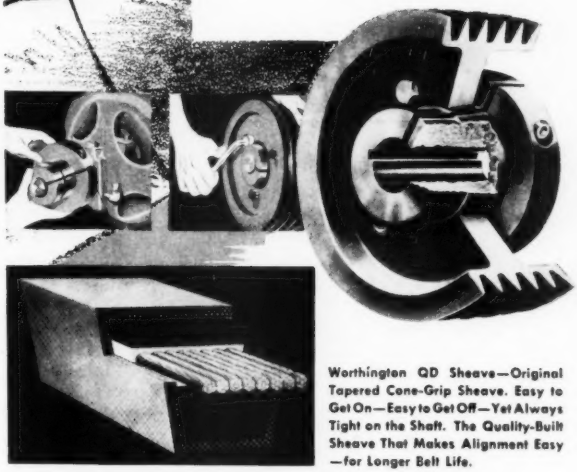
No greater grip upon the shaft



Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft. The Quality-Built Sheave That Makes Alignment Easy—for Longer Belt Life.

The original tapered cone-grip of the two-piece QD Sheave produces a tighter fit on the shaft *than any other sheave.*

The tapered-bore rim, pulled up on the tapered-cone hub, causes a cone friction grip of rim on hub; and, in turn, a positive press fit on the shaft.

Yet no sheave is as easy to put on and get off. Positioning the hub first saves juggling a heavy rim—the rim slides easily over the hub and is pulled up by the full-sized bolts. The same bolts are used as jack screws to loosen the rim for dismounting—and the hub stays put in permanent adjustment.

For Balanced Drive Performance

Specify Worthington Multi-V-Drives, with QD Sheaves and Worthington-Goodyear EC V-Belts. Each strand in the belt carries its equal share of the belt load, as each belt carries its full share of the drive load. (Goodyear EC Cord or Steel Cable V-Belts are used exclusively in Worthington Multi-V-Drives.)

Complete Range of Stock Sizes—Prompt Shipment

853 listed stock sizes in "A", "B", "C", and "D" sections, fhp to 200 hp . . . 332 listed stock sizes of EC Cord V-belts. Send coupon for latest Worthington QD Sheave bulletin.

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WORTHINGTON PUMP AND MACHINERY CORPORATION
MULTI-V-DRIVE SALES DIVISION
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MV9-1

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Company.....

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MVP-9

Only $2.98 helps put new "sell" in television advertising

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Remember, $2.98 bought a complete service in Air Express. Rates include door-to-door service and receipt for shipment—plus the speed of the *world's fastest* shipping service.

Every Scheduled Airline carries Air Express. Frequent service—air speeds up to 5 miles a minute! Direct by air to 1300 cities; fastest air-rail to 22,000 off-airline offices. Use it regularly!

Only Air Express gives you all these advantages

Nationwide pick-up and delivery *at no extra cost* in principal towns, cities.

One-carrier responsibility *all the way*; valuation coverage up to $50 without extra charge. And shipments always *keep moving*.

Most experience. More than 25 million shipments handled by Air Express.

Direct by air to 1300 cities; air-rail to 22,000 off-airline offices.

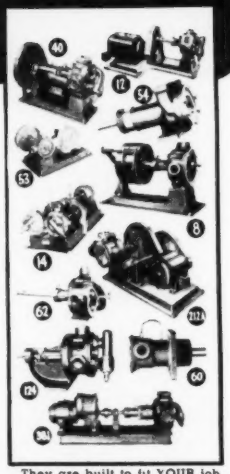
These advantages make Air Express your best air shipping buy. Specify and use it regularly. For fastest shipping action, phone Air Express Division, Railway Express Agency. (Many low commodity rates in effect. Investigate.)

SPECIFY AIR EXPRESS
GETS THERE FIRST

Rates include pick-up and delivery door to door in all principal towns and cities

AIR EXPRESS, A SERVICE OF RAILWAY EXPRESS AGENCY AND THE
SCHEDULED AIRLINES OF THE U. S.

LOWER YOUR COSTS
By Using The Right
VIKING PUMP
FOR YOUR JOB!



There is no compromise when you pick Vikings for your job. They are built in the most complete range of sizes and styles to give you the pump that will help you cut your pumping costs.

The Viking line assures you of the correct pump. No wasted power . . . no need to accept a pump not quite designed for your work . . . or one a little too small . . . or one a little too large.

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Cedar Falls, Iowa

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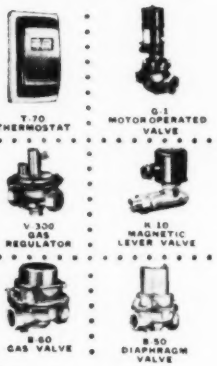

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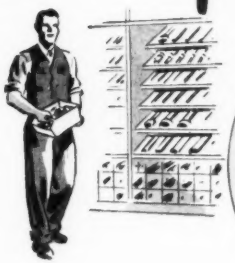
Manufacturers of Automatic Pressure, Temperature, Level & Flow Controls

Factory Branches: Birmingham (3), Boston (16), Chicago (5), Cincinnati (2), Cleveland (15), Dallas (2), Denver (10), Detroit (8), Glendale (1), Houston (6), Kansas City (2), New York (17), Philadelphia (40), Pittsburgh (22), Seattle (1), San Francisco (7), St. Louis (12), Tulsa (6). • DISTRIBUTORS IN PRINCIPAL CITIES.

Everybody's sold on PARKER-KALON SIZE-MARKED socket head cap screws



Tool crib bosses

like 'em because sizes are issued correctly and the size-mark speeds up sorting of left-over, mixed-up screws . . . eliminates waste.

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like 'em because they can spot the right size at a glance. No need to waste time guessing or gauging.

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like 'em because the correct size and thread pitch, clearly marked on the screw head, helps them learn faster . . . work faster.

*U.S. DESIGN PAT. NO. 126,406

Yes, and Sales managers

like 'em — they recognize the sales advantages of the size-mark to customers' service men in the field on reassembly jobs.

with GEAR-GRIP — fingers won't slip*

Parker-Kalon Gear Grip prevents fingers from slipping even when oily. Makes fast fingers *sure* fingers.

ONLY ON PARKER-KALON Socket Screws will you find the Size-Mark and Gear Grip . . . developed after extensive study of shop practice to speed work. Samples Free, on request. See why P-K "years ahead" Socket Screws can put your product out front, assembly-wise as well as sales-wise. Send for Stock List Now. Parker-Kalon Corporation, 200 Varick Street, New York 14, N. Y.

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IF apparatus porcelain costs have you stymied . . . on products either existing or planned . . . bring your problem to Locke.

HERE, at your disposal, is one of the world's finest and largest Ceramic Research Laboratories, staffed by experts whose porcelain "know-how" is backed by Locke's more than 55 years experience with *all* phases of porcelain design and manufacture.

FREQUENTLY Locke, in combination with your engineering department, can effect major cost reductions in apparatus porcelain by re-designing a piece so that it lends itself to modern low-cost manufacturing techniques.

SO, if you've got a problem in porcelain . . . either of a design or manufacturing nature . . . simple or complex, try us. The recommendations of our Ceramic Engineers may enable you to produce an existing piece for considerably less . . . or a new piece for much less than you expected to pay.

CONSULT your local Locke representative, or write direct. Address Department AP.

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Less costly hood design

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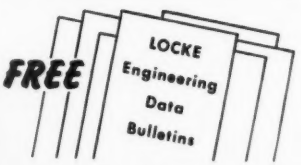

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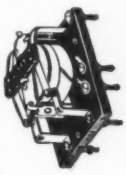

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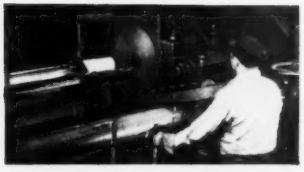

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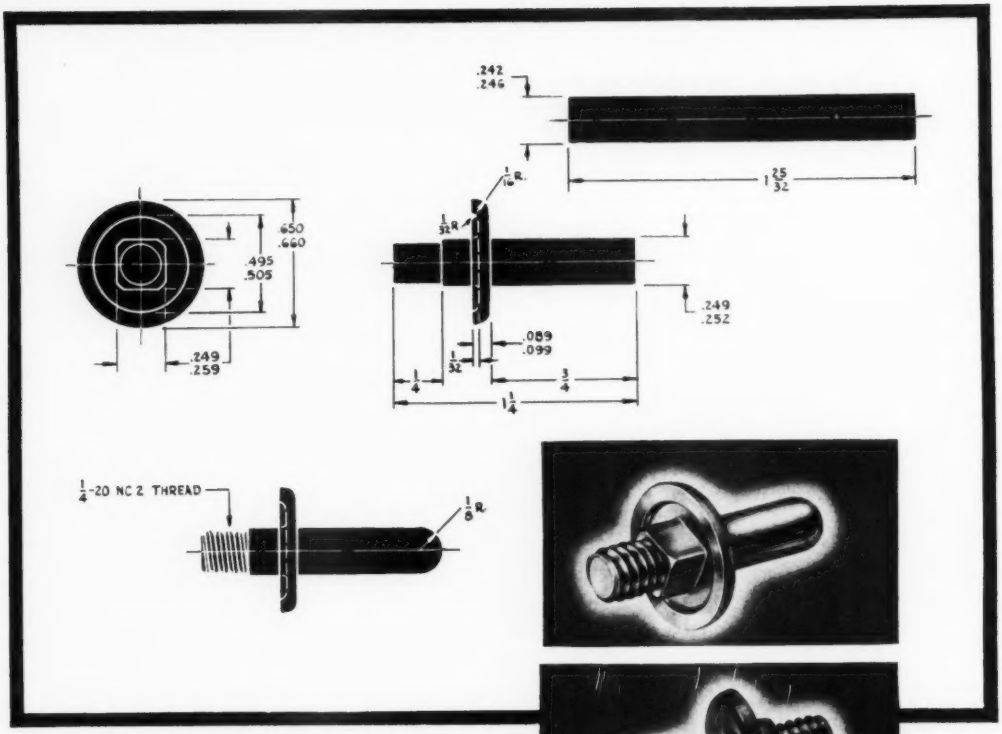

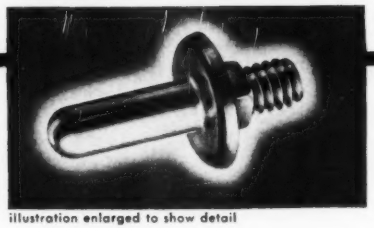

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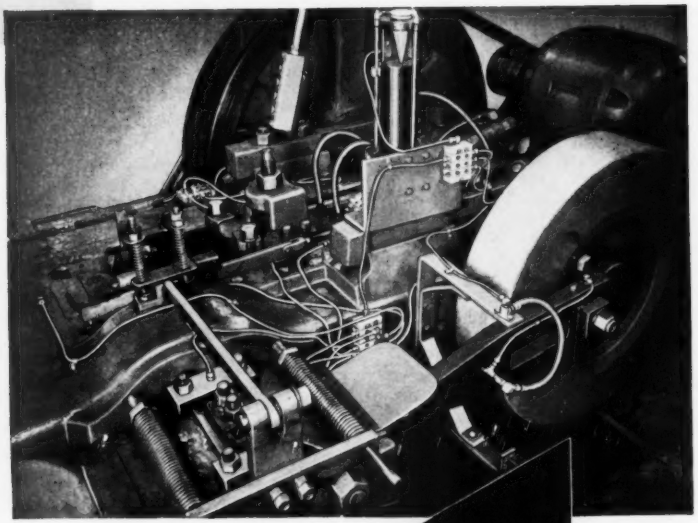

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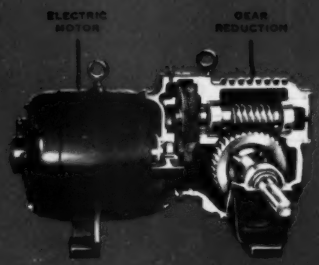

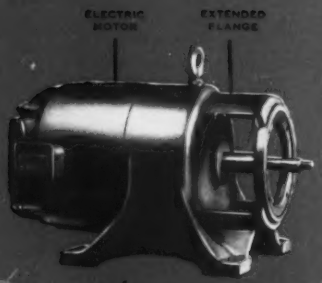

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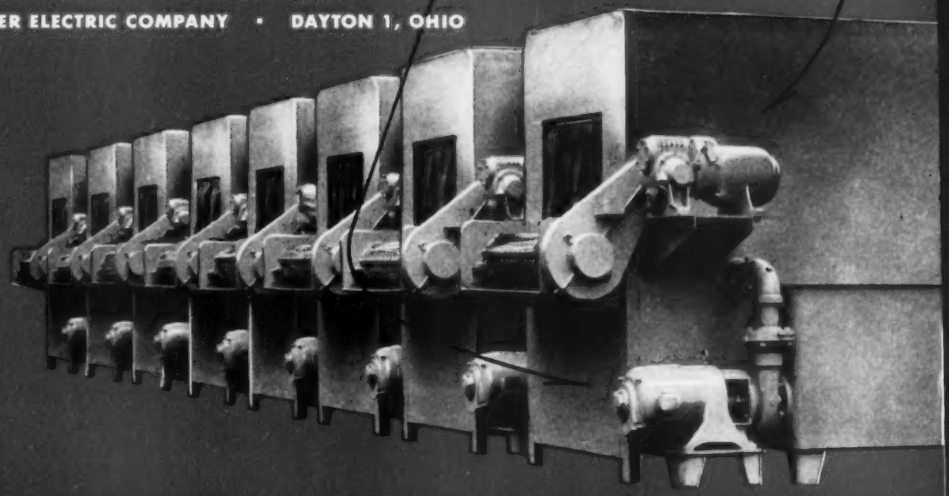

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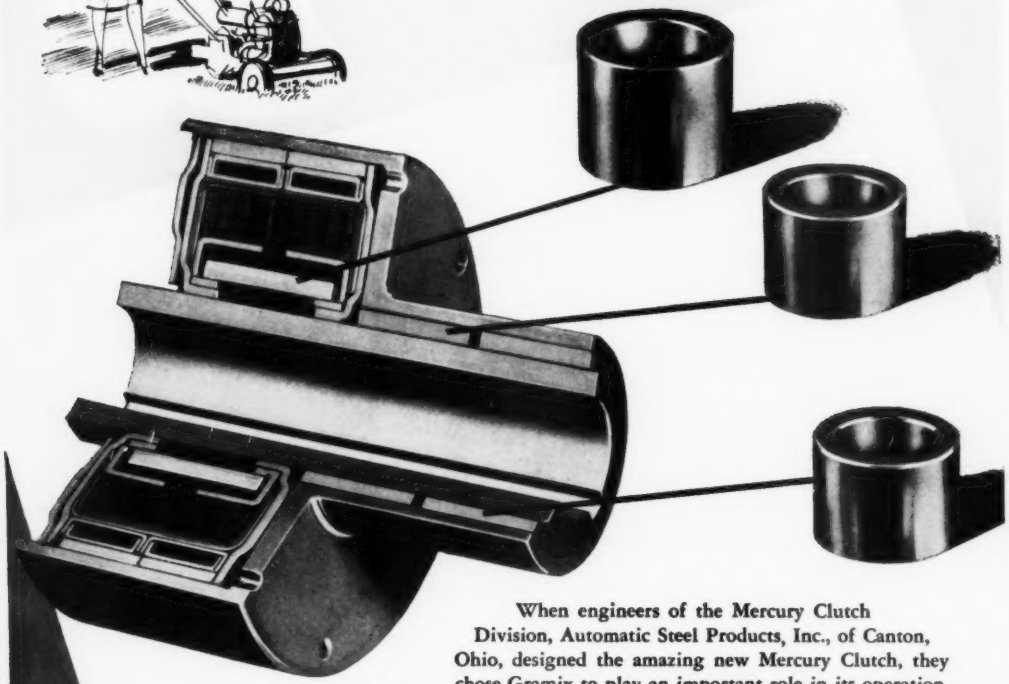

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